FISHERY RESEARCH

PROJECT 4: HATCHERY TROUT EVALUATIONS

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Project 4: Hatchery Trout Evaluations

Subproject 1: Improving Vulnerability of Rainbow Trout—A Selective Breeding Experiment
Subproject 2: Sterile Trout Investigations
Subproject 3: Fish Health and Performance Study

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ANNUAL PERFORMANCE REPORT

SUBPROJECT #1: IMPROVING VULNERABILITY TO ANGLING OF RAINBOW TROUT A SELECTIVE BREEDING EXPERIMENT

State of:	Idaho	Grant No.:	F-73-R-24 Fishery Research
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Subproject #1:	Improving Vulnerability of Rainbow Trout—A Selective Breeding Experiment		
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ABSTRACT

Tag returns from catchable size rainbow trout *Oncorhynchus mykiss* indicated that selective breeding for increased vulnerability to angling produced no measurable benefits in terms of increasing total harvest and decreasing time to harvest when compared to normal hatchery trout. Seven hundred tags were returned out of the 6,389 tags that were stocked. Three hundred sixty-five tags were returned from the vulnerable group and 335 from the normal group. First year return rate for the vulnerable group ranged from 3.0% to 26.0% and averaged 11.4%. First year return rate for the normal group ranged from 2.5% to 24.8% and averaged 10.5%. First year return rates between groups were not statistically different. The vulnerable group had a tendency to return to the creel more quickly. The mean time to harvest was 46.5 d for the vulnerable group and 50.4 d for the normal group. However, this difference was not statistically significant either. Over 50% of the tags returned were from fish caught within 50 days after stocking, and over 85% were from fish caught within 100 days after stocking.

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INTRODUCTION

The Idaho Department of Fish and Game (IDFG) plants about 3 million put-and-take rainbow trout *Oncorhynchus mykiss*, also referred to as catchables, annually. Approximately 60% of the catchables are released in lakes, reservoirs and ponds, and the remaining fish are stocked in streams and rivers. The major objective of the put-and-take program is to provide increased angling opportunity and harvest. Of the 3 million catchables stocked every year, anglers harvest about 1 million (<40%) (Teuscher et al. 1998). Assuming an optimistic 40% of the catchables are harvested, where do the remaining 60% go and what are the associated costs of producing fish that are not caught? In pure economic terms, the losses account for about $660,000 and make up 30% of the total resident hatchery budget (IDFG 1998). Fish losses also affect anglers by lowering harvest and catch rates. The substantial loss of catchables begs the question—can we improve returns (Teuscher et al. 1998)?

The IDFG has completed a number of research projects directed at improving return-to-creel of hatchery rainbow trout. Many of the studies focused on what size of rainbow trout to stock (Cuplin 1958; Mauser 1992; Mauser 1994; Teuscher 1999). Other studies evaluated fish behavior (Dillon and Alexander 1996), stocking time, release methods, and fish condition (Casey et al. 1968; Welsh et al. 1970). This report summarizes preliminary results from a three - year study and evaluates the possibility of increasing returns by selecting broodstock that exhibit high levels of angling vulnerability. The success of this project depends on meeting two assumptions. First, individual trout in the Hayspur strain (R9) broodstock population must demonstrate varying degrees of angling vulnerability. Secondly, angling vulnerability must be heritable in this broodstock (Teuscher 2000).

Individual fish exhibit varying degrees of hook-and-line vulnerability. Burkett et al. (1986) reported that largemouth bass *Micropterus salmoides* in Ridge Lake, Illinois demonstrated “high” and “low” angling vulnerability. In the four-year study, 26% of the bass were never caught, compared to 62% of the fish being caught six or more times. Hackney and Linkous (1978) also reported that largemouth bass have easily harvestable segments. Individuality of angling vulnerability has also been shown for rainbow trout. Lewynsky (1986) observed that during a nine-week fishing trial in a raceway, captures ranged from zero to five times per individual trout. About 37% of the fish were caught more than one time, and 21% were never caught. These studies indicate that some individual fish are more likely than others to be caught by hook-and-line methods, but they give no indication as to the heritability of that trait.

Angling vulnerability may be heritable. Perhaps the most commonly cited studies that link genetic contribution and angling vulnerability are strain evaluations. Strain effects on angling vulnerability have been demonstrated for largemouth bass (Zolczynski and Davies 1976; Burkett et al. 1986; Kleinsasser et al. 1990), rainbow trout (Brauhn and Kincaid 1982; Moring 1982; Hudy and Berry 1983; Dwyer and Piper 1984), cutthroat trout *Oncorhynchus clarki* (Dwyer 1990), brook trout *Salvelinus fontinalis* (Nuhfer and Alexander 1994), tilapia *Oreochromis* sp. (Yoneyama et al. 1997), and blue catfish *Ictaluras furcatus* (Tave et al. 1981). A common theme among the strain studies is that faster growing strains are more vulnerable to angling, and growth in field tests was generally higher for domesticated or hybrid stocks (Tave et al. 1981; Brauhn and Kincaid 1982; Dwyer and Piper 1984; Nuhfer and Alexander 1994; Yoneyama et al. 1997). Moreover, Umino et al. (1997) determined that genetic factors controlled aggressive feeding behavior and competitive advantage in larval crucian carp, *Carassius langsdorfii*. Similar mechanisms likely pattern the growth and ultimately the catchability of hatchery rainbow trout.

If angling vulnerability is heritable, then it should be possible to increase returns by selecting broodstock that are vulnerable to angling. In Texas ponds, angling trials revealed that a largemouth bass population possessed individuals with varying levels of angling vulnerability. Garrett (1993) then selectively bred highly vulnerable males with highly vulnerable females and wary males with wary females. The two groups of progeny were reared separately until age-1, marked, and combined into one pond. In subsequent fishing trials, the catch rate of progeny from the highly vulnerable group was twice that of the progeny from the wary group. With a similar study design, David Philipp (Illinois Natural History Survey, unpublished data) also noted that the catchability of largemouth bass could be improved through selective breeding.

MANAGEMENT GOAL

1. To increase return to the creel of put-and-take rainbow trout.

OBJECTIVES

1. To determine if Hayspur broodstock selected for their angling vulnerability produce offspring that return to angler creels more often than normal hatchery trout.

2. Estimate total return for stocked rainbow trout in 16 waters.

DESCRIPTION OF STUDY AREA

A total of 16 study sites were stocked in 2001, including 10 stream or river segments, three reservoirs, and three ponds. Study sites were located throughout southern and eastern Idaho (Figure 1). Only sites that were managed with catchables, were known to have significant fishing pressure, and were easily accessible were included in this study. Additionally, sites must have been stocked by Ashton Fish Hatchery in recent years or have been identified as whirling disease positive due to potential disease transfer concerns.

METHODS

A series of fishing trials were conducted on one-year-old rainbow trout designated to become replacement broodstock at Hayspur Fish Hatchery. All fish were Passive Integrated Transponder (PIT) tagged before fishing trials. Fish caught three or more times during the trials were uniquely marked and retained for breeding purposes. For a complete description of trials and broodstock selection procedures, see Teuscher and Alexander (1999).

During November 1999, male and female rainbow trout that were captured more than two times in the fishing trials were spawned, and their progeny were used as the experimental group in this study. A control group was also created at this time from normal Hayspur strain rainbow trout broodstock. The control group was spawned in the same manner as all production rainbow trout, and therefore was representative of catchable rainbow trout stocked by IDFG.

Normal and vulnerable eggs were transported from Hayspur to Ashton Fish Hatchery. Eggs and fry were reared separately. Due to a density and feed miscalculation during early rearing, length distributions and condition factors of the test groups became skewed. Feeding rate adjustments were made to ensure that mean size and condition of the groups before fin clipping was equal. The vulnerable group was adipose-clipped and combined with the normal group into one outside raceway until the time of stocking.

During May 2001, fish were crowded, and 6,400 catchables were randomly removed from the raceway, where they were anesthetized, tagged, and held in holding pens for 0.5 to 20 hours. One hundred trout from each group were weighed to the nearest gram and measured to the nearest mm. Each jaw tag was labeled "RTN IFG" and numbered. Jaw tag numbers identified group and stocking site. The PVC holding pens were 1.2 x 1.2 x 2.4 m (width x height x length) and were lined with 6 mm plastic hardware cloth. Immediate tag loss due to shedding or mortality was evaluated by examining raceway bottoms below the holding pens just before transport. Shed tags were reapplied to replacement trout, if observed.

From May 30 to June 6, 2001, approximately equal numbers of vulnerable and normal catchables were stocked at each of the 16 stocking locations (Table 1). At streams and rivers, fish were dipnetted from the transport tank and released at several areas to encourage dispersal of tagged fish. At ponds and reservoirs, fish were stocked through a discharge tube at one location, usually a boat ramp. Immediately after stocking, two to eight signs were posted depending on the number of access points available to anglers.

Reward incentives, press releases, personal contacts, and signs were used to encourage angler compliance in returning tags. Anglers that returned tags were entered in site-specific drawings where a single winner was awarded $50. Newspaper, radio, and television were used to disseminate information regarding the location of the study waters, the reward incentive, and the project goal. Blaze-orange signs with information pertinent to the drawing were posted near access points in all waters. Additionally, data slips with the tag return instructions were affixed to each sign to assist anglers in the tag return process. Jaw tag data were collected by mail, telephone, and field contacts by IDFG personnel. Tag number, angler address, capture location, and catch date were entered and compiled in a database.

All tags returned before December 31, 2001 were considered first year returns. Tag returns were compiled by group and study site. Additionally, the number of days from stocking to harvest was determined for each return, and a mean value was calculated for each study site. Paired *t*-tests were used to test the null hypothesis that there was no difference in the number of normal and vulnerable catchable tag returns, and there was no difference in time to harvest (d) for normal and vulnerable catchables (Dillon et al. 2000).

Although estimates of overall tagged trout return (exploitation) are not a primary goal of this study, such results are always of interest to fisheries managers. Accordingly, we corrected observed tag returns for each water by a range of values likely to encompass the true tag non-response rate (Rieman 1987). These non-response rates were 0.3, 0.36, and 0.5. The lower rate, 0.3, would represent a low response rate from anglers who harvested tagged fish. The middle value, 0.36, is the mean compliance rate of several duck banding studies that used standard non-reward tags (See Methods Subproject 3 for citations), and is a point estimate of the true compliance rate for this study in the absence of our own data. The upper value, 0.5, would represent a high response rate from anglers who harvested tagged fish.

RESULTS

At the time of stocking, mean lengths of the test groups were not statistically different (Paired t-test, P = 0.57). Mean length of the vulnerable and normal groups was 244.7 mm (SE = 2.15 mm) and 242.8 mm (SE = 2.73 mm), respectively.

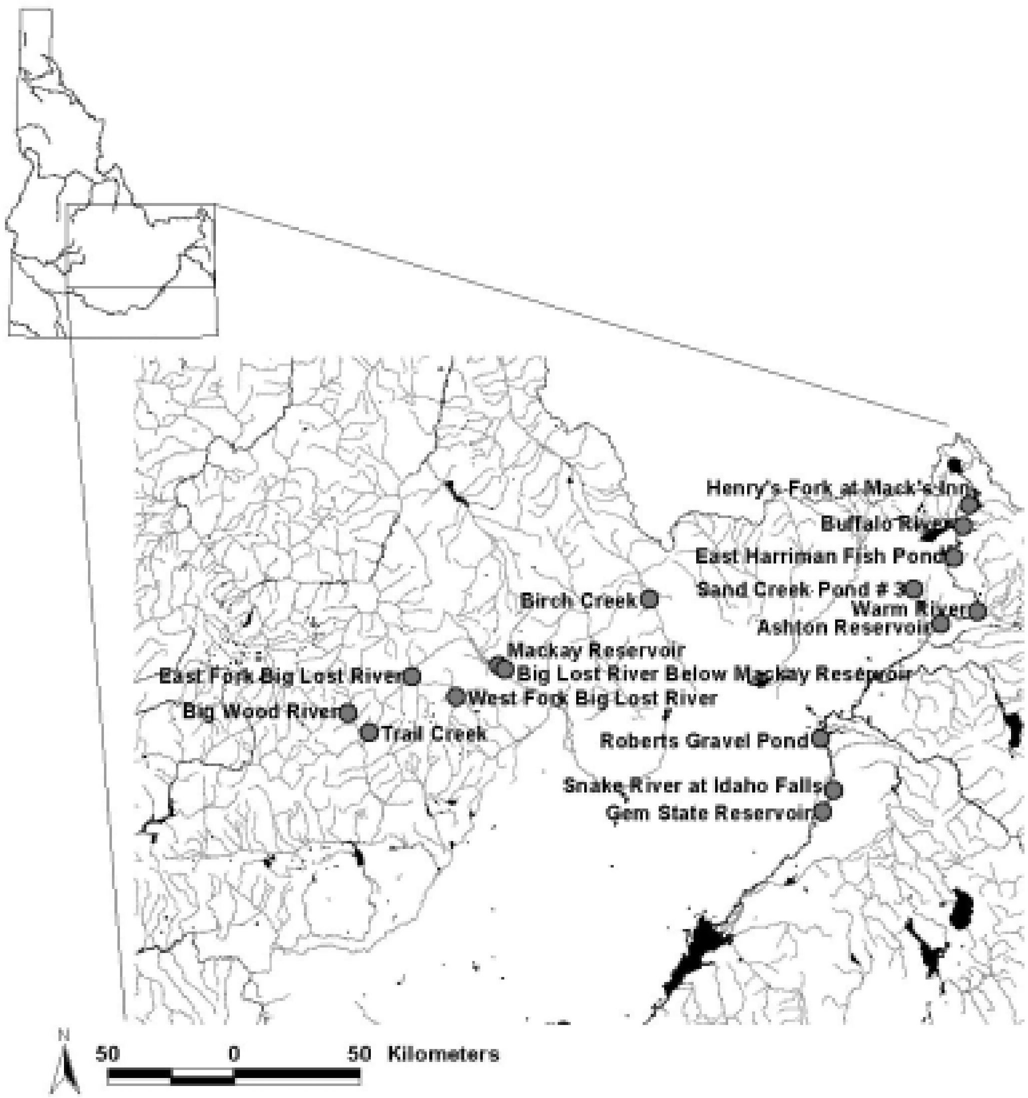

Figure 1. Locations of 16 study sites in Idaho used to compare performance of catchable size rainbow trout produced from vulnerable and normal broodstock.

Total tag returns varied widely across stocking locations, but no statistically significant difference could be attributed to variable returns from the two test groups. A ten-fold difference in return rate existed between the locations with the highest (Warm River) and lowest (Sand Creek Pond #3) returns. However, mostly small differences were seen in the relative number of tags returned between the vulnerable and normal groups within a stocking location (Table 1). The number of tags returned from the vulnerable group was higher at nine of 16 locations, whereas the number of tags returned from the normal group was higher at seven locations. Relative tag returns between the test groups were within two tags or less at seven locations and within four tags or less at nine locations. The largest relative difference occurred at the Big Lost River, where 22 more vulnerable tags were returned than normal tags. The second largest difference occurred at Roberts Gravel Pond, where nine more normal tags were returned than vulnerable tags.

Seven hundred tags were returned out of 6,389 stocked. Three hundred sixty-five tags were returned from the vulnerable group and 335 from the normal group. First year return rate for the vulnerable group ranged from 3.0% to 26.0% and averaged 11.4%. First year return rate for the normal group ranged from 2.5% to 24.8% and averaged 10.5%. First year return rates between groups were not statistically different (paired t-test, $p = 0.30$, df = 15).

The vulnerable group tended to return to the creel more quickly (Figure 2), but this disparity was not statistically significant (paired t-test, $p = 0.26$, df = 15). The mean time to harvest was 46.5 d for the vulnerable groups and 50.4 d for the normal group. Over 50% of the tags returned were from fish caught within 50 days of stocking, and over 85% were from fish caught within 100 days.

Total first year return rate (both groups combined) unadjusted for noncompliance ranged from 2.5% to 24.8% (Table 2). Eight of the 16 stocking locations had total first year adjusted return rates of less than 10%, whereas only four of the 16 stocking locations met or exceeded 15% total first year return rate. Assuming tag reporting compliance equaled the mean of past studies (36%), only four out of 16 stocking locations had adjusted return rates that met or exceeded the IDFG Fish Management Goal of 40% by number (IDFG 2001). Eight out of 16 stocking locations had adjusted return rates of 25% or less.

DISCUSSION

Although the vulnerable group returned at slightly greater levels and returned more quickly than the normal group, none of the differences was statistically significant. Certainly, the small observed differences were not important from a management perspective. This result contradicts conclusions drawn by other researchers who have artificially selected for specific behavioral traits in other species. In fishing trials, Garrett (1993) showed varying levels of vulnerability to angling in largemouth bass. Selective breeding of the highly vulnerable fish produced progeny that were more likely to be caught, especially when brood fish had been caught two, three, or four times. Gerlai and Csanyi (1994) were able to increase and decrease a behavioral movement pattern in paradise fish *Macropodus opercularis* by selecting parents who had high and low expressions of this behavior. The movement pattern was inherited strongly by the F1 generation, and selection in subsequent generations did not change the behavior substantially. David Philipp of the Illinois Natural History Survey (unpublished data) has demonstrated that largemouth bass angling vulnerability is quite heritable, and that selective breeding for more catchable fish can be demonstrated with F_1 and F_2 crosses.

Table 1. Stocking location, stocking date, number of tagged fish stocked, number of tags returned by anglers, and first year return rate from each of 16 locations stocked with catchable rainbow trout produced from parents that were highly susceptible to angling (Vulnerables) and Hayspur strain broodstock (Normals).

		Vulnerables			Normals		
Stocking Location	**Date Stocked 2001**	**# Stock**	**# Return**	**1st Year Return Rate (%)**	**# Stock**	**# Return**	**1st Year Return Rate (%)**
Warm River	May 30	200	52	26.0	200	47	23.5
Big Lost River	June 1	200	50	25.0	200	28	14.0
Roberts Gravel Pond	June 4	200	30	15.0	200	39	19.5
N F Big Wood River	June 5	200	29	14.5	200	31	15.5
Trail Creek	June 5	200	27	13.5	200	23	11.5
Birch Creek	June 4	199	24	12.1	200	23	11.5
Henry's Fork at Mack's Inn	May 30	199	23	11.6	200	24	12.0
Ashton Reservoir	May 30	200	22	11.0	200	25	12.5
Snake River at Idaho Falls	May 31	200	21	10.5	200	15	7.5
Harriman Fish Pond	May 30	199	16	8.0	199	9	4.5
Mackay Reservoir	June 1	200	15	7.5	200	16	8.0
West Fork Big Lost River	June 5	200	13	6.5	198	8	4.0
Gem State Reservoir	May 31	199	13	6.5	199	12	6.0
E F Big Lost River	June 5	200	13	6.5	199	14	7.0
Buffalo River	May 30	200	11	5.5	199	17	8.5
Sand Creek Pond 3	May 30	200	6	3.0	199	4	2.0
Total		3196	365	11.4	3193	335	10.5

There are several possible reasons for our contradictory results. The previous studies examined the difference between low and high expressions of a particular behavior. Due to space and monetary constraints, we sought only to compare the difference between the normal Hayspur brood fish progeny and those whose parents showed high vulnerability to angling. It is possible that selection for more vulnerable catchables could occur, but the effect might not be large for test fish when compared to our normal or average fish. Thus, differences in experimental design could explain the disparate results of the present effort compared to other studies. Additionally, by conducting our selection experiments (fishing trials) in raceways on domesticated stock, we may have selected for unknown traits that would be undesirable in the wild, such as excessive aggression, hyperactivity, or low predator avoidance. If inherited by progeny it could lower the return potential of the vulnerable group and would mask any benefits supplied through selective breeding.

Although our return to creel estimates only include first year returns and are not adjusted for non-response, several stocking locations are well below (first year return rate <7%) the stocking goal of 40% return to creel by number. Second year returns of catchables are usually low (Cooper 1952; Reimers 1963), especially in streams, and are unlikely to influence these results. A second trial using an additional group of streams should probably be done, given the substantial investment in selecting vulnerable broodstock. A second year of null results would certainly strengthen our findings. If compliance is between 30% and 50%, adjusted return-to-creel rates for these locations would be less than 14-21%. These locations include Gem State Reservoir, Buffalo River, and Sand Creek Pond #3, as well as the East and West forks of the Big Lost River. With a similar study design that included some of the same streams, total return rate for diploid and triploid rainbow trout was 17% (Dillon et al. 2000), which is 6% higher than for this study. Similarly, mean time to harvest was poorer for this test than for the previously mentioned study. Mean time to harvest for diploid and triploid trout was 30.2 and 28.1 d, respectively. Mean time to harvest in this study was nearly 20 days longer for both groups, which would allow for additional mortality prior to harvest and lower tag returns. It is possible that the drought conditions of 2001 reduced survival and negatively influenced tag returns. Alternatively, angler use, harvest rates, or interest in returning tags may have decreased during this time period.

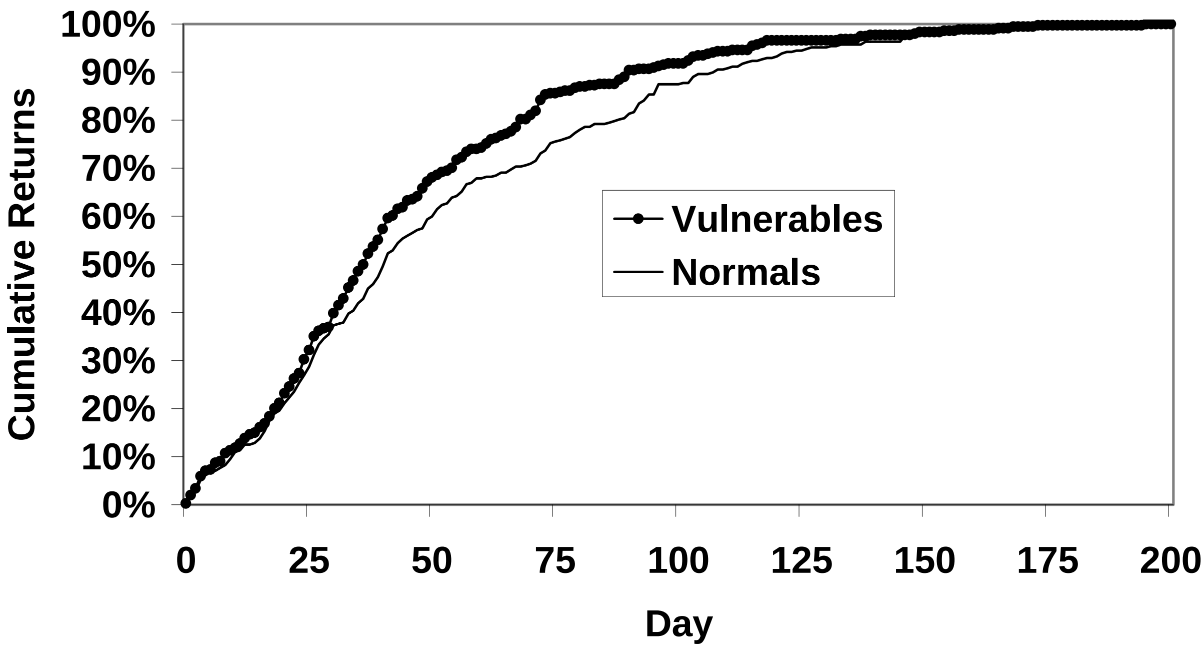

Figure 2. Cumulative first-year returns to creel over time for vulnerable and normal hatchery rainbow trout in 16 stocking locations in Idaho combined.

RECOMMENDATIONS

1. Continue collecting tag returns for an additional year to allow estimation of total harvest and survival.

2. Conduct a second and final year of stocking evaluation.

Table 2. Stocking location, total number of tagged rainbow trout stocked and returned by anglers, first year return rate, and adjusted return rate. Adjust return rate was calculated by dividing the first year return rate by a range of compliance estimates (C).

	Totals			Adjusted Return Rate (%)		
Stocking Location	# Stock	# Return	1st Year Return Rate (%)	C=0.3	C=0.36	C=0.5
Warm River	400	99	24.8	83	69	50
Big Lost River	400	78	19.5	65	54	39
Roberts Gravel Pond	400	69	17.3	58	48	35
N F Big Wood River	400	60	15.0	50	42	30
Trail Creek	400	50	12.5	42	35	25
Ashton Reservoir	400	47	11.8	39	33	24
Birch Creek	399	47	11.8	39	33	24
Henry's Fork at Mack’s Inn	399	47	11.8	39	33	24
Snake River at Idaho Falls	400	36	9.0	30	25	18
Mackay Reservoir	400	31	7.8	26	22	16
Buffalo River	399	28	7.0	23	19	14
E F Big Lost River	399	27	6.8	23	19	14
Gem State Reservoir	398	25	6.3	21	17	13
Harriman Fish Pond	398	25	6.3	21	17	13
West Fork Big Lost River	398	21	5.3	18	15	11
Sand Creek Pond 3	399	10	2.5	8	7	5
Total	6389	700	11.0	36.5	30.4	21.9

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ANNUAL PERFORMANCE REPORT
SUBPROJECT #2: STERILE TROUT EVALUATIONS

State of: Idaho

Grant No.: F-73-R-24 Fishery Research

Project No.: 4

Title: Hatchery Trout Evaluations

Subproject #2: Sterile Trout Investigations

Contract Period: July 1, 2001 to June 30, 2002

ABSTRACT

Increased growth rates, improved survival, and genetic protection of wild stocks have been suggested as possible benefits of stocking triploid (i.e., sterile) fish. I examined relative growth and survival of triploid and diploid rainbow trout in high mountain lakes. Comparisons of catch, catch per unit effort (CPUE), and mean lengths from the pilot study lakes to other lake surveys indicated that the diploid and triploid groups stocked in 1999 were not fully recruited to our sampling gears during 2001. During 2001 surveys, mean length of the diploid group (248 mm) was slightly longer than the triploid group (240 mm). In contrast, a large weight difference existed, with the mean weight of the diploid group (167 mm) exceeding that of the triploid group (143 mm). Stocking of 16 additional high lakes with mixed sex diploid and triploid fingerling rainbow trout occurred in late summer 2001. Lakes will be sampled initially in 2004. For triploid induction monitoring at Hayspur Fish Hatchery, sample size determination calculations revealed that sample size and precision are related in a negative exponential fashion, and that 13 samples are needed for a 3% error bound on the overall induction estimate.

Experimental thermal shock treatments on Henry's Lake hybrids (female Yellowstone cutthroat *Oncorhynchus clarki bouvieri* X male rainbow trout *O. mykiss*) produced highly variable induction and low survival rates. Induction rates ranged from 17.2% to 100%. Although induction rates exceeding 80% occurred for individual replicates within 26°C and 27°C treatments, higher mean rates occurred in the 28°C treatments. Mean survival rate increased at higher treatment temperatures. The highest mean survival rates from egg to swim up fry of 24.3% and 25.0% occurred at the 28°C treatments. In the reverse hybrid cross (female rainbow trout X male Yellowstone cutthroat) experiment, induction rates were 100%, but mean survival was less than normal hybrid crosses.

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INTRODUCTION

Physiology, hatchery performance, and production techniques for triploid salmonids are widely published. Benfey (1999) reviewed the available literature on triploid fish and cited over 200 publications. The popularity of the subject stems from the fact that triploid fish are functionally sterile, and the common assertion is that sterility provides a fisheries or aquaculture benefit. In an aquaculture setting, triploid salmonids produced by temperature or pressure shock suffer increased mortality and reduced growth during early life stages (Solar et al. 1984; Happe et al. 1988; Guo et al. 1990; Oliva-Teles and Kaushik 1990; Galbreath et al. 1994; McCarthy et al. 1996). Despite early rearing disadvantages, triploid performance appears to improve with age. Several investigators reported enhanced rearing performance in terms of growth and food conversion for age-1 and older triploids (Lincoln and Scott 1984; Bye and Lincoln 1986; Boulanger 1991; Habicht et al. 1994; Sheehan et al. 1999).

Unlike the breadth of review in aquaculture, published literature on the performance of triploid salmonids in natural environments is sparse. Brock et al. (1994) and Simon et al. (1993) reported lower growth and survival for triploid rainbow trout *Oncorhynchus mykiss* compared to diploid controls. In contrast, triploid brook trout *Salvelinus fontinalis* and kokanee *Oncorhynchus nerka* demonstrated the potential for increased longevity in lake habitats (Parkinson and Tsumura 1988; Warrillow et al. 1997). Return-to-creel was similar for triploid and diploid rainbow trout stocked in 18 Idaho streams (Dillon et al. 2000). Teuscher (2000) reported higher return rates of triploid rainbow trout compared to diploid rainbow trout in two Idaho reservoirs. Lastly, Cotter et al. (2000) argued that stocking triploid Atlantic salmon *Salmo salar* reduced genetic impacts to wild populations because fewer triploid fish returned to spawning habitats. These studies provide some background for evaluating the performance of triploid salmonids in natural environments. However, their limited replication and contradicting results fail to fully address the performance of triploid salmonids stocked for angling opportunities.

The genetic conservation of wild populations is a management priority for the Idaho Department of Fish and Game (IDFG). The IDFG recently established a policy to stock only triploid rainbow trout in systems where reproduction between wild and hatchery fish was possible (IDFG 2001). Implementation of the above-noted policy has resulted in the widespread stocking of triploid rainbow trout in hundreds of Idaho high mountain lakes, where slow growth and difficult environmental conditions are often encountered. It has been suggested by experts that triploid fish may not perform well in stressful high mountain lake environments (J. Johnston, Washington Department of Fish & Game, personal communication). It is important to evaluate the performance of triploid rainbow trout in these fisheries so that fisheries managers can adjust stocking strategies if necessary.

In this progress report, we compared preliminary survival and growth of triploid and diploid rainbow trout stocked as part or a pilot study in four central Idaho high mountain lakes and document initiation of a full-scale study on 16 additional waters. In addition, we summarize efforts to produce triploid trout at Henry's Lake hatcheries in 2001 and to develop an induction monitoring plan for rainbow trout egg production at Hayspur Fish Hatchery.

RESEARCH GOAL

1. To minimize genetic risks to indigenous rainbow trout and cutthroat trout *O. clarki* in Idaho waters from hatchery trout and enhance hatchery-supported lake and reservoir fisheries.

OBJECTIVES

1. Evaluate relative survival and growth of diploid and triploid trout in high mountain lakes in Idaho.

2. Develop methods for producing triploid rainbow trout X Yellowstone cutthroat trout for Henry's Lake.

3. Develop an induction monitoring program for thermal shocked rainbow trout produced at Hayspur Fish Hatchery.

METHODS

Performance of Triploid Trout in High Mountain Lakes

Pilot Study

McCall Regional Management personnel purchased all-female diploid and pressure-treated (triploid) all-female Kamloops strain rainbow trout eggs from Trout Lodge commercial fish hatchery. Eggs were transported to McCall Hatchery and incubated. Resultant fry were reared in 1 m tanks until they reached 50 mm and then transferred to raceways. Prior to stocking, the diploid and triploid fish groups were grit marked with green and red fluorescent dye, respectively. Fish were held for two weeks to monitor retention. Initial marking success was 94% for the triploid group (red) and 98% for the diploid group (green). Equal numbers of diploid and triploid fish were stocked into four lakes near McCall, Idaho with fixed-wing aircraft. On October 15, 1999, 500 diploid and 500 triploid fry were stocked into Maki, Golden, and Snowslide lakes, whereas 250 diploid and 250 triploid fry were stocked into Crystal Lake.

Lakes were surveyed with floating gillnets and angling from July 16 to 24, 2001. The experimental gillnets used had 19, 25, 30, 33, 38, and 48 mm bar mesh panels and were 46 m long by 1.5 m deep. Typically, two gillnets were set in the early afternoon and pulled the following morning. While the nets fished, the two- or three-person crew used spin- and fly-fishing gear to collect additional samples.

Captured fish were identified to species, measured to the nearest millimeter, and weighed to the nearest gram. All rainbow trout were examined for grit mark presence under a portable fluorescent lantern (Model #UVL-4, UVP, Inc.). Examination for grit dye was conducted in the absence of light, either under the dark of night or within an industrial-strength black plastic garbage bag. Small sample sizes prevented statistical tests, and only simple descriptive statistics concerning fish lengths and weights are presented.

Full-Scale Diploid Vs. Triploid Assessment

Regional fishery managers and U.S. Forest Service personnel provided high mountain lake information that facilitated study site selection. Only lakes scheduled for stocking in 2001 were considered for stocking with test fish. Test fish were not stocked in drainages where conflicts with native or wild populations were possible or in lakes where brook trout populations were established. We preferentially selected lakes that were from 5 to 10 acres in surface area and had reasonable access from roads, and yet were remote enough to keep harvest to a minimum level. Additionally, past surveys must have indicated that lakes were capable of supporting stocked trout. Sixteen lakes were selected throughout central Idaho (Figure 3). All test lakes are managed under the general trout regulation of six fish per day with no length limit, except for Blackwell and Brush lakes, which are managed under the trophy regulation of two fish per day with none under 508 mm. We attempted to sample all sites prior to stocking to assess whether they possessed the traits listed above. Lakes were surveyed from July 24 to August 15, 2001. Fish were sampled and measured with the same methods described in the previous section.

Mixed-sex rainbow trout eggs were produced from 1:1 pairings at Hayspur Fish Hatchery. After fertilization, egg lots were split. Half the eggs were reared normally and will be used as the control in this study. The other half was placed in a 26°C water bath at 20 minutes post-fertilization (MAF) and thermal-shocked for 20 minutes to induce triploidy (Teuscher et al. 1998). Eggs were incubated, reared in 1 m tanks, and then transferred to raceways. Prior to grit marking, both groups were adipose clipped to indicate inclusion in this study when sampled in the field, and the diploid and triploid groups were grit marked with green and red fluorescent dye, respectively. Overall mortality due to marking was low. Fish were held for two weeks and grit retention was measured for both groups. Length and weight of 100 fish were measured immediately prior to stocking. From August 30 through September 15, 2001, each lake was stocked from a fixed-wing airplane. Lakes will be sampled in 2004. Depending on results, a subsample may also be sampled in 2005 to evaluate potential longevity differences.

Production of Sterile Trout

Hayspur Monitoring Program

Large-scale production of triploid Hayspur and Kamloops rainbow trout at Hayspur Fish Hatchery has become a reality. Mean induction rates for eight lots from the 2000 production year exceeded 96% (Bob Esselman, unpublished data). However, these samples were selected in a non-random fashion and may not be indicative of the true mean induction rate. To ensure that overall induction rates are precisely estimated, a monitoring program was developed. This program dictates how many samples are necessary to estimate mean induction rates within a specific bound and provides a framework for selecting those samples.

In an average year, Hayspur Fish Hatchery produces about nine million triploid rainbow trout eggs. Eggs are thermal shocked in heath trays that hold about 18,000 eggs; thus, approximately 500 heath trays must be thermal shocked to produce the total. Theoretically, each heath tray is composed of different quality eggs and receives a slightly different thermal treatment, despite efforts to standardize handling procedures. These and other unknown factors may create variable induction rates.

After consulting with a statistician, we determined that two-stage cluster techniques were most appropriate for selecting samples. However, due to the cost of flow cytometry, we were forced to assume that a 40 fish sample per heath tray accurately estimated the induction rate of an entire tray. This assumption allowed us to estimate sample sizes with one-stage cluster sampling techniques (Scheaffer et al. 1996). A sample population of induction rates was created from past experiments and production testing that used the 26°C, 20 minutes after fertilization (MAF), 20 min duration recipe and heat bath constructed in 2000 (Megargle and Teuscher 2000). The framework for selecting samples was designed to sample throughout the entire production year by sampling at least once or twice a month and randomly selecting one tray for each of those day(s). The sample size needed to estimate overall triploid induction rates was calculated as (Scheaffer et al. 1996):

$$n = \frac{Ns_p^2}{ND + s_p^2} \quad \text{where,} \quad D = \frac{B^2\overline{M}^2}{4} \quad \text{and} \quad s_p^2 = \frac{\sum_{i=1}^{n}\left(a_i - \hat{p}m_i\right)}{n-1}$$

where,

N = the number of clusters in the population
n = the number of clusters selected in a simple random sample
B = Error bound
m_i = the number of elements in cluster i
$\overline{M}$ = M/N = the average cluster size for the population
a_i = the number of elements that possess the characteristic of interest
$\hat{p}$ = The population proportion
s_p^2 = variance of the population proportion

Henry's Lake Hybrids

In 2001, we planned to test thermal and pressure treatment sterilization techniques for inducing triploidy in Henry's Lake hybrids. However, due to an equipment failure, pressure treatment experiments were canceled. Fertilized eggs for the experiments were produced by combining the gametes of one male Hayspur-strain rainbow trout and three female Henry's Lake cutthroat trout *O. c. bouvieri*. Eggs were then split into three heath trays and thermal shocked with various temperature and MAF combinations. Each temperature and MAF combination or treatment was replicated three times. Temperature of the heat bath was set at 26°C, 27°C, or 28°C and the eggs were placed in the bath at 15 or 20 MAF. All eggs were thermal shocked for 20 minutes.

Additionally, an experiment was conducted using the gametes from four female Hayspur-strain rainbow trout and four male Henry's Lake cutthroat. These eggs were split into four replicates and thermal shocked at 27°C: 10 MAF: 20 min.

All eggs were heat shocked, incubated, hatched, and reared at Henry's Lake Fish Hatchery. Eggs were enumerated at eyed and hatch stages to determine survival. Blood samples were collected from each treatment group, and ploidy levels were determined with flow cytometry at Washington State University by Paul Wheeler.

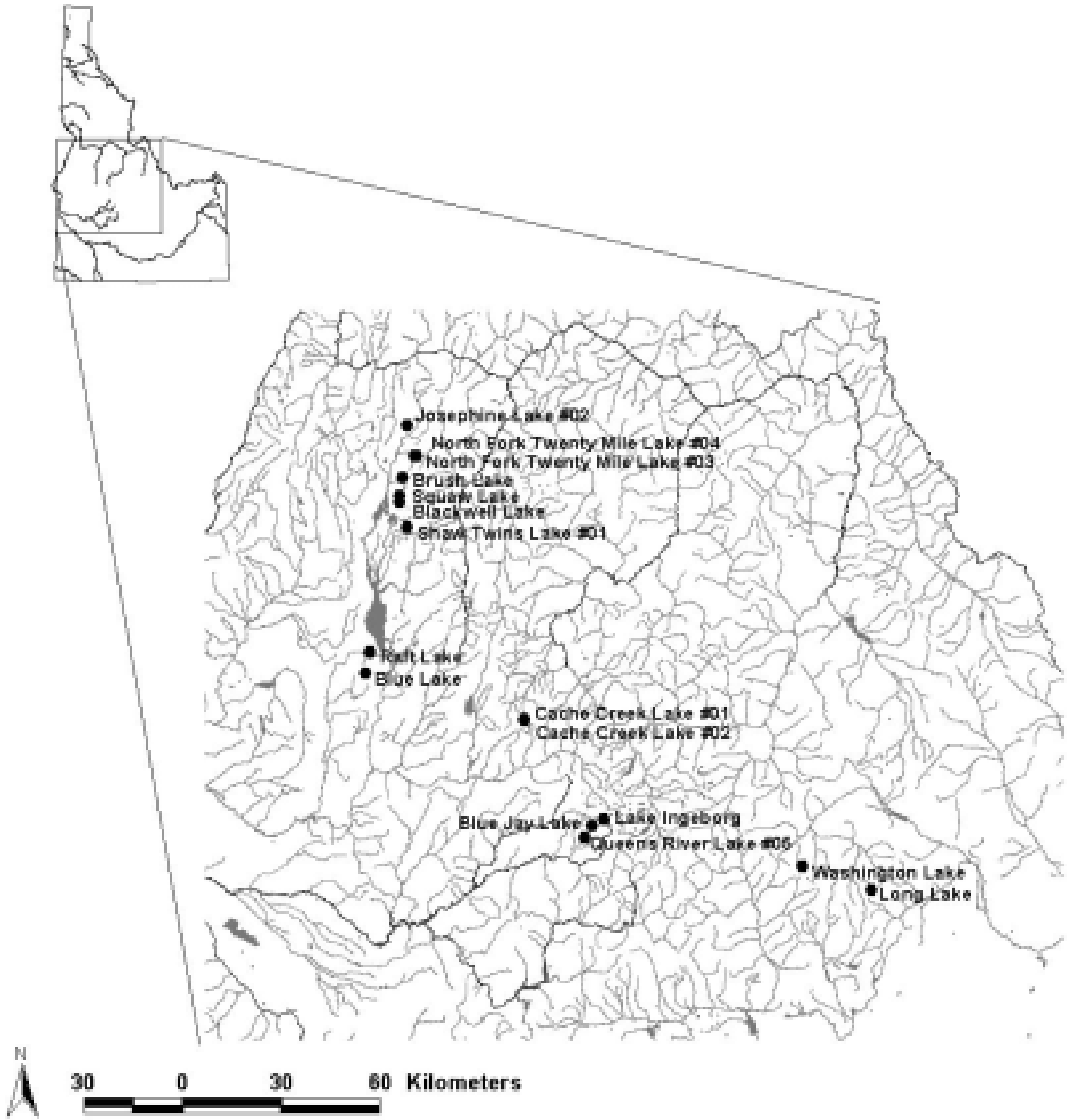

Figure 3. Locations of 16 mountain lakes in Idaho used to compare the relative performance of mixed sex diploid and mixed sex triploid rainbow trout.

RESULTS

Performance of Triploid Trout in High Mountain Lakes

Pilot Study

I sampled four pilot study lakes from July 16 through 24, 2001. No rainbow trout were collected from Snowslide Lake, which may have been due to the presence of a wild brook trout population. Fourteen triploid and 20 diploid rainbow trout were collected from the other three lakes, most of which were sampled from Maki Lake. Hook and line sampling was more effective than gill net sets in terms of total catch and CPUE (Table 3)

For all lakes combined, mean length of the diploid group ($\bar{X}$ = 248 mm; n = 20; Figure 4) was slightly longer than the triploid group ($\bar{X}$ = 240 mm; n = 14). Length differences were small between groups within a lake, except in Golden Lake, where mean length of the triploids ($\bar{X}$ = 228 mm; n = 4; Figure 4) was 20 mm less than the diploids ($\bar{X}$ = 248 mm; n = 10). In contrast, a large weight difference existed between the groups. The mean weight of the diploid group ($\bar{X}$ = 167 g; n = 20) exceeded that of the triploid group ($\bar{X}$ = 143 g; n = 20) by 24 grams. In Maki and Golden Lakes, where sample sizes were the largest, the weight differences equaled 30 grams.

Table 3. Combined catch, effort, and catch per unit effort (CPUE) of diploid and triploid rainbow trout surveys conducted on four high mountain lakes that were stocked with diploid and triploid rainbow trout fry during October, 1999. The number of triploid rainbow trout sampled, inclusive, is listed within parentheses in the total catch column.

		Gill Net			Hook-and-Line			Total		
Lake Name	Survey Date	Catch	Effort (Hours)	CPUE	Catch	Effort (Hours)	CPUE	Catch	Effort (Hours)	CPUE
Golden	7/24/01	6	34	0.18	8	7	1.23	14(4)	41	0.34
Maki	7/18/01	4	15	0.26	13	10	1.30	17(9)	25	0.67
Snowslide	7/17/01	0	8	0.00	0	6	0.00	0(0)	14	0.00
Crystal	7/16/01	2	6	0.33	1	9	0.11	3(1)	15	0.20
Totals		12	63	0.19	22	32	0.69	34(14)	95	0.36

Full-Scale Diploid Vs. Triploid Assessment

Sixteen lakes were selected as potential sites for this evaluation from regions 3, 4, and 6. Seven of these lakes were sampled prior to stocking to determine if they possessed the criteria listed in the methods section. Two lakes, Lake Creek Lake #11 and Shirts Lake, were removed from the study because no overwinter survival of stocked trout was evident (Table 4). Lake Creek Lake #11 probably winter killed, as it is shallow and high in elevation (3047 m). Shirts Lake was removed due to a highly abundant brook trout population, and rainbow trout stocked during 1998 did not survive. North Creek Lake was removed, as it was dewatered. Washington Lake, NF Twenty Mile Lake #3, and NF Twenty Mile Lake #4 were added as replacements. Although we were unable to sample fish in Raft Lake, I chose to include it as a test lake because a few fish were observed.

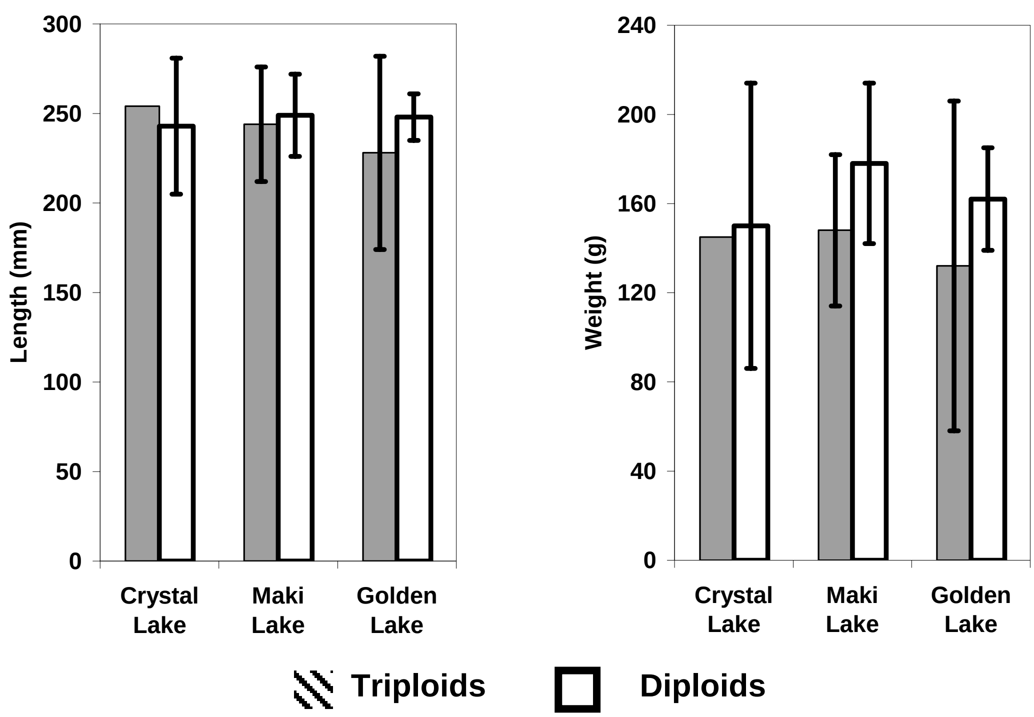

Figure 4. Mean length and weight of triploid and diploid rainbow trout that were stocked during October 1999 and sampled in July 2001. Sample sizes are listed in Table 4. Errors bars indicate $\pm$ SE.

Catch, CPUE, and species composition differed among the seven lakes sampled. The highest catch and CPUE were recorded in Shirts Lake, where brook trout were abundant and mean length and weights were the smallest (Table 5). Cutthroat trout were only sampled from Squaw Lake and were longer on average than fish from all the other lakes. Long and Blackwell Lakes possessed relatively abundant rainbow trout populations. With a similar amount of effort, fewer rainbow trout were captured from Blue Lake. Blue Lake is within one mile of a good gravel road and probably receives the highest angling pressure of all the study lakes.

During lake surveys, the gill net mesh size a fish was entangled in showed a positive, significant relationship to fish length (Figure 5; Fish length in mm = 192.92 + 3.61 * mesh size in mm; R^2 = 0.23; P < 0.01). Mean fish length increased steadily from a minimum of 258 mm in the 19 mm panel to a maximum of 348 mm in the 38 mm panel. Mean length in the largest bar measure panels, 40 and 46 mm, decreased from the maximum by 14 and 28 mm. This anomaly may be due to the few fish sampled in the largest panels

Prior to stocking, flow cytometry testing revealed that the induction rate of the triploid group was 98% (n = 40). No testing was conducted on the diploid group. Marking success at the time of stocking was 94.0% for the diploid group and 98.0% for the triploid group. Mean length of the triploid group was 66.6 mm, whereas the mean length of the diploid group was 65.2 mm.

Mean weights were equal at 2.96 g. There were no statistical differences in length or weight (two sample t-test, length: $p = 0.10$; weight: $p = 0.97$). Lakes were stocked from August 30 through September 15, 2001. The location of the final 16 test lakes is shown in Figure 3 and basic descriptions of the lakes' characteristics are found in Table 6.

In order to monitor grit retention and determine the sex ratios of the test groups, over 200 fish of each group that possessed grit dye were moved to Eagle Fish Hatchery and held in 0.5 m circular tanks. The ratio of males to females was 1.38:1. Retention monitoring two and a half months after marking revealed that both colors of grit dye were persistent. Retention in a random sample of 50 fish was 100.0% for triploids and 94.0% for the diploids.

Table 4. Catch, effort, and catch per unit effort (CPUE) of all species combined for surveys conducted on perspective study waters from July 25 through August 15, 2001.

	Gill Net			Hook and Line			Total		
Lake Name	**Catch**	**Effort (Hours)**	**CPUE**	**Catch**	**Effort (Hours)**	**CPUE**	**Catch**	**Effort (Hours)**	**CPUE**
Blackwell	29	21	1.41	5	5	1.00	34	26	1.33
Blue	8	19	0.43	1	8	0.13	9	27	0.34
Lake Creek #11	0	3	0.00	0	3	0.00	0	6	0.00
Raft	0	19	0.00	0	8	0.00	0	26	0.00
Shirts	21	15	1.38	32	6	5.57	53	21	2.52
Squaw	3	2	1.50	9	2	6.00	12	4	3.43
Long	29	21	1.38	12	8	1.50	41	29	1.41
Totals	**90**	**100**	**0.90**	**59**	**40**	**1.48**	**149**	**139**	**1.07**

Table 5. Species sampled, mean length, mean weight, and stocking history of lakes in Idaho sampled in 2001.

Lake Name	Last Stocking	# of Fry Stocked	Species Sampled	Sample Size	Length (mm)	95% CI	Weight (g)	95% CI
Blackwell	08/26/00	725	RBT	34	268	(246-285)	212	(178-250)
Blue	08/25/00	510	RBT	9	306	(276-335)	307	(219-395)
Lake Ck. #11	09/18/98	500	—	0	—	—	—	—
Long	09/05/98	3,000	RBT	41	324	(305-343)	371	(316-427)
Raft	09/03/96	500	—	0	—	—	—	—
Shirts	08/31/98	500	BRK	53	190	(184-197)	70	(63-78)
Squaw	08/18/98	500	CUT	12	362	(335-389)	—	—

Table 6. Description of study waters in Idaho stocked with diploid and triploid rainbow trout fry in 2001.

Lake Name	IDFG Catalog #	Size (ha)	Elevation (m)	UTM East	UTM North
Blackwell	09-00-00-0366	5.3	2101	578983	4979970
Blue Jay	10-00-00-0242	2.3	2610	653034	4865169
Blue	09-00-00-0256	5.0	2222	568962	4917491
Brush	09-00-00-0387	7.5	2187	579765	4988951
Cache Creek #01	07-00-00-0843	1.4	2357	627195	4902755
Cache Creek #02	07-00-00-0844	1.8	2326	627235	4903140
Crystal	09-00-00-0351	4.0	2164	581753	4977979
Golden	09-00-00-0353	4.0	2268	584099	4979583
Josephine #02	07-00-00-0408	5.0	2262	580707	5008135
Lake Creek #11	15-00-00-0188	1.4	3047	271573	4842718
Ingeborg	10-00-00-0306	9.5	2723	657142	4867972
Long	15-00-00-0187	5.6	2916	271639	4844740
Maki	09-00-00-0383	3.9	2220	585576	4980498
NF Twenty Mile #03	09-00-00-0397	6.5	2396	584535	4996711
NF Twenty Mile #04	09-00-00-0398	3.6	2384	584025	4996677
Queens River #05	10-00-00-0232	3.1	2520	650480	4860818
Raft	09-00-00-0276	2.5	2139	570275	4925479
Shaw Twins #01	09-00-00-0331	2.8	2310	582231	4971043
Shirts	09-00-00-0271	3.5	2254	569825	4922944
Snowslide	09-00-00-0353	8.5	2187	584097	4981435
Squaw	09-00-00-0370	2.1	2166	578899	4982333
Washington	15-00-00-0158	1.2	2854	729729	4853171

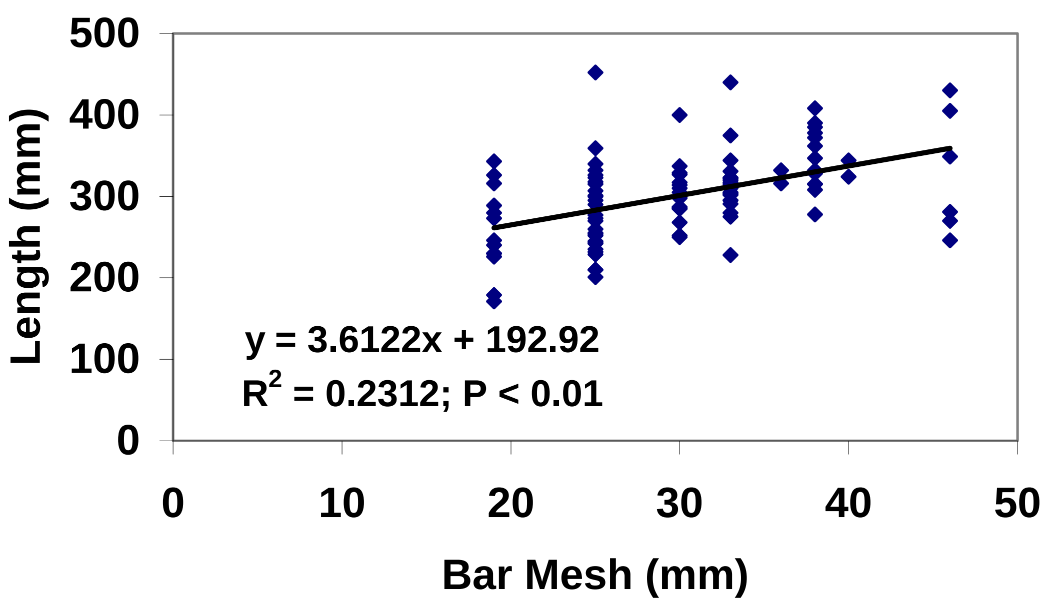

Figure 5. Relationship between bar mesh size and length of rainbow or cutthroat trout captured during high mountain lake surveys.

Production of Sterile Trout

Hayspur Monitoring Program

Induction rates varied between 83 and 100% (n = 14). The sample mean and variance were 96.0% and 0.3%, respectively. Sample size calculations revealed that sample size (# of heath trays from which 40 fish samples are drawn) and precision are related in a negative exponential fashion (Figure 6). Eight randomly selected heath tray samples are needed to place a 4% error bound on the overall mean induction rate. Thirteen samples are needed for a 3% error bound. Substantial increases in sample size and cost are needed to increase precision beyond that point.

Depending on what level of precision is acceptable, the appropriate number of samples will be drawn from months where substantial egg production occurs. Random number tables will be used to determine which day(s) to sample and what heath tray to sample on that day. Approximately 100 eggs from each selected heath tray will be shipped to the wet lab at Eagle Fish Hatchery where they will be reared to an appropriate size for blood sampling. Forty blood samples from each of the selected trays will be shipped to Paul Wheeler at WSU and analyzed using flow cytometry. After all samples have been collected and analyzed, an overall induction rate and bound will be calculated for each year using a one-stage cluster sampling formula.

Henry's Lake Hybrids

Experimental thermal shock treatments on Henry's Lake hybrids produced highly variable induction rates. Induction rates ranged from 17.2 to 100.0% (n = 16; Table 7). Although induction rates exceeding 80% occurred for individual replicates within the 26 and 27°C treatments, higher mean rates occurred in the 28°C treatments. Mean induction rates for the two 28°C treatments exceeded 92.0%.

Survival rates followed a similar trend. Considerable variability existed within treatments. Survival from the egg to swim up fry stage ranged from 0.0 to 64.0%. Mean survival rate increased at higher treatment temperatures. The highest mean survival from egg to swim up fry of 24.3 and 25.0% occurred at the 28°C treatments.

In the reverse hybrid cross experiment, survival from egg to swim up fry was less than 10.0% in two of the four replicates and 0.0% in the other two. Induction rates were 100.0% in the replicates that survived.

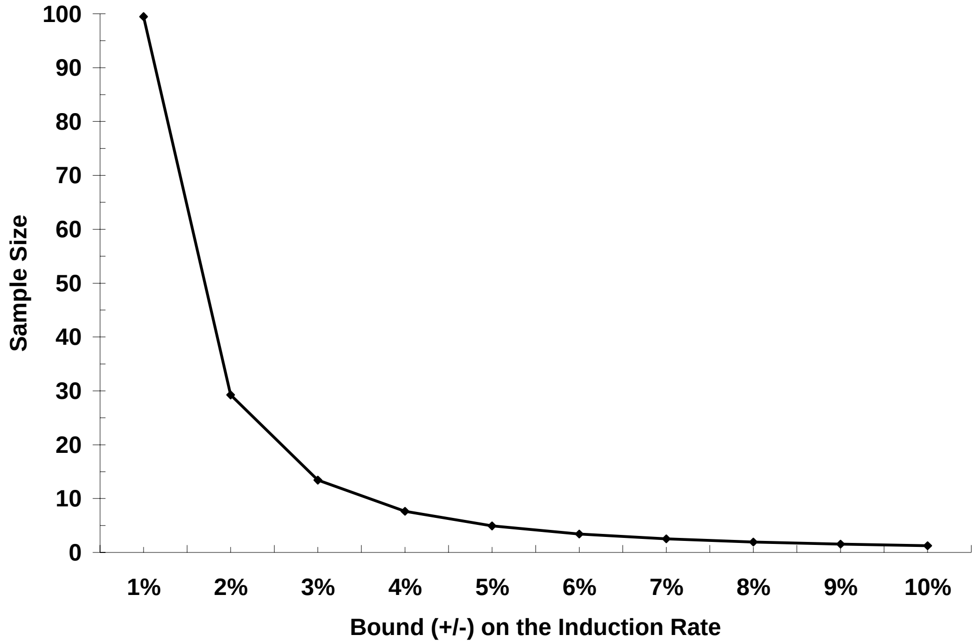

Figure 6. Relationship between sample size (# of heath trays) and the error bound that may be placed on an induction rate assuming 40 fish are sampled per heath tray.

Table 7. Survival and triploid induction rates of Henry's Lake hybrids using various temperature and minutes after fertilization (MAF) treatments.

Replicate	Temp (ºC)	MAF	Duration (min)	Survival from Egg to Eye Up (%)	Survival from Eye up to Button Up (%)	Survival from Egg to Swim Up (%)	Induction (%)
1	26	15	20	1.8	53.8	1.0	35.7
2	26	15	20	2.1	26.3	0.6	80.0
3	26	15	20	85.1	29.4	25.0	17.2
1	27	15	20	60.1	13.1	7.9	89.3
2	27	15	20	0.0	0.0	0.0	0.0
3	27	15	20	84.8	63.9	54.2	44.8
1	28	15	20	88.1	48.8	43.0	100.0
2	28	15	20	75.5	13.8	10.4	76.7
3	28	15	20	80.8	24.2	19.6	100.0
1	28	20	20	0.0	0.0	0.0	0.0
2	28	20	20	86.3	74.2	64.0	96.7
3	28	20	20	14.3	78.0	11.1	100.0
1	27[a]	10	20	17.2	52.6	9.1	100.0
2	27[a]	10	20	51.7	55.0	28.4	100.0
3	27[a]	10	20	0.0	0.0	0.0	0.0
4	27[a]	10	20	0.0	0.0	0.0	0.0

[a] Experiments were conducted with a reverse hybrid cross (rainbow trout eggs X cutthroat trout milt).

DISCUSSION

Comparisons of catch, CPUE, and mean lengths from the pilot study lakes to the other lake surveys indicated that the diploid and triploid groups stocked in 1999 were not fully recruited to our sampling gears during 2001. Hook and line catch exceeded the gillnet catch in the pilot study lakes, whereas this trend was reversed in the non-pilot study lakes. The CPUE for each method showed a similar trend with the gill nets being more efficient as mean length increased. In the pilot study lakes, hook and line CPUE exceeded gill net CPUE by 3.6 times. In contrast, hook and line CPUE exceeded gill net CPUE by only 1.6 times in the non-pilot study lakes. Seemingly, hook and line methods were more efficient at capturing smaller fish. The analysis of gill net mesh size and fish length revealed that few fish less than 250 mm were caught by any mesh size. Since mean fish lengths of fish captured in all of the pilot study lakes were just under 250 mm, only the larger diploids and triploids were available for capture in the pilot study lakes. These trends all indicate that, at age-2, the diploid and triploid groups were underrepresented by our sampling gears, and sampling of high mountain lakes should first occur when stocked fish reach age-3 or older.

Diploids and triploids were relatively equal in length at the time of sampling in 2001, but the diploid group was 15% heavier. Megargle and Teuscher (2000) saw a similar difference in a comparison of diploid and triploid rainbow trout in a lowland reservoir. In Treasureton Reservoir, mean length of the two groups was equal at 24 months, but the diploid group was 100 g heavier. Eventually, this trend was reversed as diploid fish matured and put more energy into gonadal development and reproduction. In 16 Alberta high mountain lakes, mean weight of age-2 diploid rainbow trout ranged from 117 to 2,066 g (Donald and Anderson 1982). These lakes were larger, on average, and from 1,000 to 1,400 m lower in elevation than our study waters, but this range of weights indicates that the growth potential of trout in the pilot study lakes is low.

Stocking of diploid and triploid rainbow trout fry in 16 high mountain lakes was completed and a full-scale evaluation of the triploid rainbow trout stocking program is now underway. Recaptures of marked fish will have to be adjusted to account for differential grit marking rates and grit loss. Field dissection and gonad examination in 2004 and 2005 of all fin-clipped rainbow trout will account for grit marking loss and for non-induced fish marked as triploids.

Variable induction rates and poor survival were still evident in thermal shock treatments conducted on Henry's Lake hybrids. Although some improvements were noted in the 27 and 28°C treatments, induction rates were variable. An improved water bath and the 28°C treatment will be used next year for production of Henry's Lake hybrids. Induction rate monitoring from these lots should determine whether the variable induction rates were caused by equipment malfunction. Additionally, pressure treatments will also be tested to determine whether early survival can be improved without sacrificing induction rates.

Induction monitoring of triploid rainbow trout at Hayspur Fish Hatchery has been shifted from a research to a fish health and hatchery responsibility. Managers have decided that a 3% bound on the overall induction rate is desirable. This necessitates that the eggs from 13 randomly-selected heath trays be shipped to the wet lab at Eagle Fish Hatchery and reared to a size appropriate for blood sampling. Paul Wheeler at Washington State University will determine induction rates with flow cytometry. The results will allow estimation of the overall induction rate and the associated variance using the following, one-stage cluster sampling formulae (Scheaffer et al. 1996; see Methods section for variable definitions).

$$\text{mean induction rate} = \hat{p} = \frac{\sum_{i=1}^{n} a_i}{\sum_{i=1}^{n} m_i} \quad \text{variance} = v(\hat{p}) = \left(\frac{N-n}{Nn\bar{M}^2}\right) s_p^2 \quad s_p^2 = \frac{\sum_{i=1}^{n}\left(a_i - \hat{p} m_i\right)}{n-1}$$

RECOMMENDATIONS

1. Resample the pilot study lakes in 2002 and 2003 when fish should be fully recruited to our gillnets.

2. Sample 16 high mountain lakes in 2004 and 2005 to evaluate survival and growth of diploid and triploid rainbow trout across central Idaho.

3. Evaluate pressure treatment as a method for providing more consistent induction and higher survival rates in Henry's Lake hybrids.

4. Hayspur Fish Hatchery and Eagle Fish Health Laboratory personnel should collect 100 eggs and 40 blood samples from each of 13 randomly selected heath trays during each spawning season for estimation of overall induction rates at Hayspur.

ACKNOWLEDGMENTS

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ANNUAL PERFORMANCE REPORT
SUBPROJECT #3: FISH HEALTH AND PERFORMANCE

State of: Idaho

Grant No.: F-73-R-24, Fishery Research

Project No.: 4

Title: Hatchery Trout Evaluations

Subproject #3: Fish Health and Performance Study

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ABSTRACT

We compared the performance (relative tag returns) of Kamloops rainbow trout catchables from four of Idaho Department of Fish and Game's largest production hatcheries. Additionally, we examined fish health prior to stocking to determine if prestock fish health was related to post-stock performance. Fish health was evaluated using an organismic index, autopsy-based assessment. Jaw-tagged rainbow trout from Nampa, Hagerman-Riley Creek, Hagerman-Tucker Springs, and American Falls hatcheries were stocked concurrently in 16 lakes and reservoirs located throughout south-central Idaho in 1999 and 2000. In all time periods evaluated, returns were significantly different among hatcheries. The disparity of returns among hatcheries suggests the hatchery environment can affect the performance of stocked trout; however, the differences among hatcheries were inconsistent. This suggests some hatchery influences were neither predictable nor hatchery specific. Generally, American Falls Hatchery trout provided relatively high total returns ($\bar{X}$ = 18.9% in 1999 and 21.0% in 2000), including exceptionally high carryover ($\bar{X}$ = 4.5% from 1999 to 2000 and 1.1% from 2000 to 2001). Nampa Hatchery trout performed well in 1999 in terms of total returns ($\bar{X}$ = 17.5%), but relatively poorly in 2000 ($\bar{X}$ = 12.8%); therefore, the overall comparative performance of Nampa trout was inconclusive. Hagerman trout consistently provided 12.5-13.8% returns, which on average, is lower than the other hatcheries. An explicit explanation for the lower average returns of Hagerman hatchery was not determined, but rearing trout at low densities may provide better returns of stocked trout. The hatchery source for catchable trout was a significant source of variation (up to 17%) in stocked trout returns among the waters examined, but most of the variation in returns was explained by water specific influences. Prestock fish health and the relative abundance of large zooplankton were unrelated to catchable returns.

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INTRODUCTION

Each year, Idaho Department of Fish and Game (IDFG) hatcheries stock approximately three million catchable rainbow trout *Oncorhynchus mykiss*, of which about one million are harvested by anglers (Teuscher et al. 1998). The IDFG hatchery program accounts for a large portion of the total fishery budget (IDFG 2001), while providing angling opportunity in many waters of the state where yield fisheries cannot be supported with natural production. Given the cost of the hatchery program, every effort should be made to maximize the angling opportunity provided by IDFG hatcheries.

In the past, IDFG has completed numerous studies designed to maximize harvest of hatchery trout. Several studies have investigated the possible relationship between fish size (Mauser 1992, 1994; Teuscher 1999), stocking time, stocking methods, fish conditions (Casey et al. 1968; Welsh et al. 1970), and fish behavior (Dillon and Alexander 1996) to angler success. However, no evaluations have examined the hatchery-to-hatchery variability in fish health, quality, and return-to-creel.

The 2001-2005 management plan provides guidelines to maximize the efficiency of the catchable rainbow trout program. The guidelines include: 1) concentrating releases of catchables in easily accessible, heavily fished water; 2) timing releases to coincide with peaks in fishing pressure, 3) publicizing the location of catchable trout streams; and 4) producing a consistently high-quality product at the hatcheries (IDFG 2001). One aspect of quality, in terms of IDFG management objectives, would be a stocked trout that provides a return-to-creel rate of at least 40% by number (IDFG 2001). For the purposes of this study, such return rates will subsequently be referred to as performance.

The hatchery environment can affect the post-stock survival of fish stocked in the natural environment. Hatchery environments can influence the expression of behavioral traits (Vincent 1960; Moyle 1969; Swain and Riddell 1990) and post-stock survival. Rearing densities, the quantity and quality of the water supply, and the disease and pathogen prevalence can directly impact the health of hatchery-reared trout. Idaho Department of Fish and Game hatcheries vary widely in physical design, water source, disease status, and fish culture practices. A range of potential environmental stressors is found among hatcheries, which suggests that post-stock vigor and survival to creel may also vary with the source of stocked trout. For example, anecdotal observations by several IDFG regional fishery managers suggest that some fish provided from Hagerman Hatchery were unhealthy and likely contributed very little to the fishery. Although studies directly linking prestock hatchery conditions to return-to-creel are limited, it can be assumed that hatchery-specific fish performance exists. If IDFG can identify a hatchery facility that consistently produced lower quality trout, focus can be placed on making improvements at that facility. In addition, the recent fiscal situation has resulted in substantial cutting of hatchery budgets. If IDFG budgets remain tight or continue to decline in the future, an assessment of hatchery trout performance would be useful if production needs to be cut.

The purpose of this study is to determine if there are consistent differences in return to angler creel rates of catchable rainbow trout stocked. This was the final year of a three-year study to determine if the returns of stocked trout differ among hatcheries. Specifically, this research evaluated the relative return-to-creel of catchable rainbow trout (CRBT) from four IDFG hatchery sources. Fish health was also evaluated to determine if fish health at stocking was a useful predictor of return-to-creel.

RESEARCH GOAL

The goal of this research is to maximize the angler harvest of CRBT produced and stocked by IDFG hatcheries.

OBJECTIVES

1. To determine if there are significant differences in the return to creel rate of CRBT produced at three IDFG hatcheries: Nampa, Hagerman (both Riley Creek and Tucker Springs sources), and American Falls.

2. If a significant difference is found in return rate, determine if prestock fish health can predict subsequent harvest of stocked trout.

3. Determine if the ZPR index can be used to predict relative carryover of stocked CRBT.

4. Estimate total return rates for stocked catchable rainbow trout in 16 waters.

DESCRIPTION OF STUDY AREA

Lakes and reservoirs were stocked with tagged trout in 1999 and 2000. Lakes and reservoirs representing a wide range in size, elevation, and productivity were included in the study and were located throughout Southern Idaho (Table 8, 9; Figure 7). Site-specific temperature and dissolved oxygen data are reported in Appendix A. Only sites that were managed with CRBT, were known to have significant fishing pressure, and were easily accessible were considered for this study. Regional fishery managers provided angling effort information for potential study areas. Sites 1-16 were stocked in 1999. Site 2 was eliminated from the study in 2000 due to disease concerns and was replaced with site 17 (Figure 8).

Four IDFG sources of Kamloops CRBT were chosen for this evaluation. The hatchery sources included: 1) Nampa, 2) Hagerman-Riley Creek (Hag-R), 3) Hagerman-Tucker Springs (Hag-T), and 4) American Falls. These hatcheries were selected because they 1) reared sufficient numbers of CRBT, 2) reared a large portion of the CRBT for IDFG, and 3) were centrally located. Although Hag-T and Hag-R were not unique facilities, they will be referred to as hatcheries from this point forward. Two sources of Hagerman CRBT were used because Hagerman Hatchery has two water sources for fish production. The water source for Hag-T and Hag-R is well water (Tucker Springs) and surface water (Riley Creek), respectively. Historically, fish reared in the Hag-R surface water have had acute and chronic health problems (Doug Burton, IDFG, personal communication). All four hatchery sources were used in 1999, and three were used in 2000. Hag-T was eliminated from the study in 2000 because no catchable-sized trout were available from that water source.

Table 8. Description of study waters.

Study waters	IDFG catalog #	Elevation (m)	Surface area (ha)
Upper Payette Lake	09-00-00-0392	1,701	128
Cove Arm Res.	05-00-00-0168	750	31
Dog Creek Res.	11-00-00-0121	1,100	38
Magic Res.	11-00-00-0131	1,469	1,529
Lava Lake	11-00-00-0118	1,570	8
Mann Creek Res.	08-00-00-0003	878	114
Park Center Pond	10-00-00-0117	823	6
Dierkes Lake	05-00-00-0208	1,052	40
Mountain Home Res.	05-00-00-0180	1,000	164
Blair Trail Reservoir	05-00-00-0184	1,058	6
Little Camas Res.	10-00-00-0130	1,500	589
Sublett Reservoir	05-00-00-0228	1,625	46
Deep Creek Res.	14-00-00-0112	1,573	74
Roseworth Res.	05-00-00-0202	1,426	607
Featherville Dredge P.	10-00-00-0161	1,372	1
Hawkins Reservoir	05-00-00-0234	1,567	22

Table 9. Water quality of study waters including pH, ambient conductivity, Secchi disk, and plankton productivity data. Data were collected in August 1999 and 2000. Data are presented as 1999 data/2000 data.

Study waters	pH	Cond.[a]	Secchi (m)	ZPR[b]	ZQI[c]
Upper Payette Lake	9.4/-na-	20/-na-	8.2/-na-	0.1/-na-	0.0/-na-
Cove Arm Res.	8.9/9.2	410/413	2.7/1.5	0.9/0.8	0.9/0.9
Dog Creek Res.	8.5/9.2	350/351	2.7/0.3	0.0/0.0	0.0/0.0
Magic Res.	8.8/9.0	185/219	4.5/3.5	0.5/0.9	0.1/0.5
Lava Lake[e]	10.4/-na-	600/-na-	1.0/-na-[d]	-na-/-na-	-na-/-na-
Mann Creek Res.	8.8/8.6	160/174	1.9/1.5	0.3/0.8	0.1/0.3
Park Center Pond	9.2/8.7	140/118	1.1/1.0	0.0/0.0	0.0/0.0
Dierkes Lake	9.4/9.2	700/700	1.8/1.3	0.0/0.0	0.0/0.0
Mountain Home Res.[e]	9.3/9.3	70/ 77	1.7/-na-	1.0/-na-	0.6/-na-
Blair Trail Reservoir	9.9/9.5	100/ 46	0.4/0.5	0.0/0.0	0.0/0.0
Little Camas Res.	8.8/9.6	85/ 87	2.2/0.5	0.6/0.4	1.2/1.1
Sublett Reservoir	9.2/8.2	450/460	4.8/3.5	0.1/0.0	0.1/0.0
Deep Creek Res.	8.8/7.8	300/306	4.5/2.5	0.5/0.8	0.5/0.3
Roseworth Res.	8.7/8.5	85/ 86	1.9/1.0	0.5/0.5	0.6/0.6
Featherville Dredge P.	9.1/8.6	80/ 74	5.5/4.0	0.0/0.0	0.0/0.0
Hawkins Reservoir[e]	8.8/9.4	700/335	2.9/2.5	0.8/-na-	1.2/-na-

[a] Conductivity (micro semens / cm)
[b] ZPR = zooplankton biomass (750μ mesh net) / zooplankton biomass (500μ mesh net). The greater the ZPR ratio the more favorable the forage conditions.
[c] ZQI = ((zooplankton biomass (750μ mesh net) + zooplankton biomass (500μ mesh net))*ZPR. The ZQI is a measure that includes both abundance and zooplankton size.
[d] Secchi reading to bottom; too shallow to sample plankton.
[e] Drought conditions precluded sampling in 2000

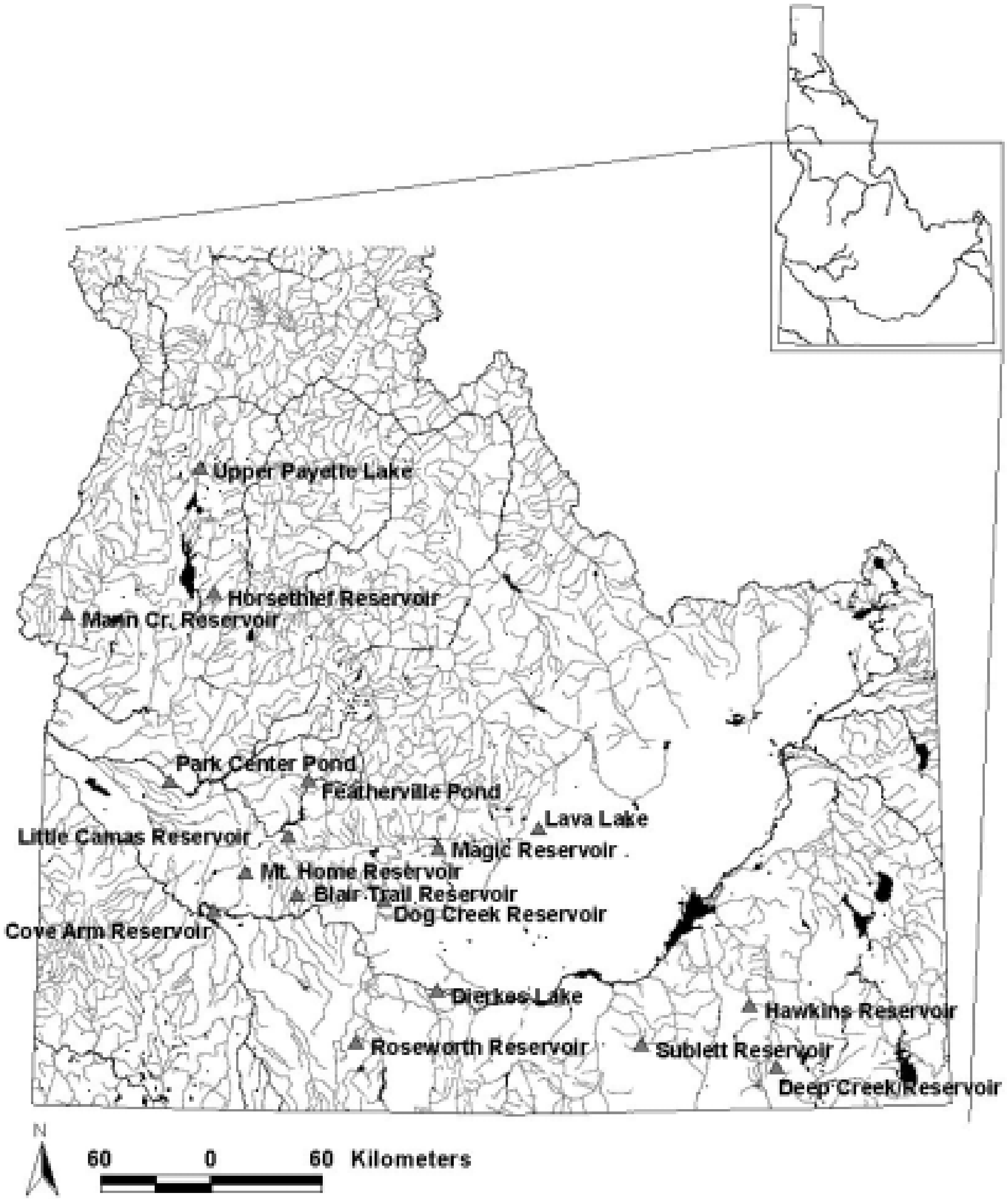

Figure 7. Location of study waters: 1) Mann Creek Res., 2) Upper Payette Lake, 3) Park Center Pond, 4) Cove Arm Res., 5) Blair Trail Res., 6) Little Camas Res., 7) Featherville Dredge Pond, 8) Dog Creek Res., 9) Magic Res., 10) Dierkes Lake, 11) Roseworth Res., 12) Mountain Home Res., 13) Lava Lake, 14) Sublett Res., 15) Hawkins Res., 16) Deep Creek Res., and 17) Horsethief Res. (replaced Upper Payette Lake in 2000).

METHODS

The optimal sample size (number of study waters) needed for this study was determined in an a priori power analysis. Past tag-return data (Teuscher 1999) were used to determine the optimal sample size needed to minimize Type II errors. It was estimated that a sample size of 16 sites would provide adequate protection against Type II errors ($1-\beta = 0.75$) and detect a 20% difference in returns among hatcheries (Megargle and Teuscher 2000).

Trout used in this study were selected from all raceways that contained catchable-sized (23-25 cm total length) Kamloops rainbow trout. In each hatchery, one raceway containing CRBT was systematically selected once per week to assure all raceways were represented in the analysis. If the selected raceway was partitioned, then fish were stocked from a randomly selected section. Two to five study waters were stocked from each of the selected raceways. Those waters stocked from the same raceway in the same year are hereafter referred to as stock groups.

Three thousand, two hundred CRBT were tagged at each hatchery in both 1999 and 2000. Fish were crowded and randomly removed from the raceway, where they were anesthetized, measured for total length (TL mm), jaw tagged (size 8 Monel butt-end tag), and held in holding pens for up to three days. Every fish was measured for length in 1999, but a subsample (n = 100) was taken in 2000. One hundred trout were measured for length per stock group (Table 10). The wooden holding pens were 1.2 X 1.2 X 2.4 m (width X height X length) and were lined with 6 mm plastic hardware cloth in 1999. However, due to the extreme weight of the wooden pens, they were replaced in 2000 with identical sized pens that were framed with 5.1 cm PVC pipe and lined with nylon netting. Tag loss due to shedding or mortality was monitored to provide an accurate count of tagged fish stocked. Shed tags were reapplied to other trout if they were observed prior to transport. Each hatchery planted 200 tagged trout into each water for a total of 800 and 600 tagged trout being stocked per water in 1999 and 2000, respectively (Table 11; Appendix B).

Transport time for each stock effort was standardized among hatcheries. In most instances, the tagged trout were loaded into fish transport trucks simultaneously at all hatcheries. The travel time discrepancy among hatcheries may have introduced bias if no compensations were made; therefore, transport truck drivers with the shortest drive time were required to hold the fish in the transport truck at the hatchery to standardize the time fish spent in the transports. Minor differences in transport time were made up at the plant site, and each water was usually planted concurrently.

Reward incentives, press releases, and signs were used to encourage angler compliance in returning tags. Anglers that returned tags were entered in site-specific drawings where each winner was awarded $50. Newspaper, radio, and television were used to disseminate information regarding the location of the study waters, the reward incentive, and the project goal. Blaze-orange signs with information pertinent to the drawing were posted near access points in all waters. Additionally, data slips with the tag return instructions were affixed to each sign to assist anglers in the tag return process. Jaw-tag data were collected by mail, telephone, and field contacts by IDFG personnel. Tag number, angler address, and date of catch data were entered and compiled in a Microsoft® Access database.

Table 10. Plant group, water, date fish were tagged and stocked, and number of fish tagged and measured for length at Nampa, Hag-R, and American Falls hatcheries in 2000.

Plant Group	Water	Tag Date	Stock Date	No. Tagged	No. Measured
1	Lava L.	April 24, 2000	April 24, 2000	200	100
	Dierkes L.		April 25, 2000	200	
	Mt. Home Res.		April 26, 2000	200	
2	Dog Creek Res.	April 27, 2000	April 27, 2000	200	100
	Park Center P.		April 28, 2000	200	
3	Blair Trail Res.	May 1, 2000	May 1, 2000	200	100
	Sublett Res.		May 2, 2000	200	
	Cove Arm Res.		May 3, 2000	200	
4	Little Camas Res.	May 4, 2000	May 4, 2000	200	100
	Deep Cr. Res.		May 5, 2000	200	
5	Roseworth Res.	May 8, 2000	May 8, 2000	200	100
	Manns Cr. Res		May 9, 2000	200	
	Hawkins Res.		May 10, 2000	200	
6	Magic Res.	May 11, 2000	May 11, 2000	200	100
	Featherville P.		May 12, 2000	200	
7	Horsethief Res.	May 22, 2000	May 22, 2000	200	100

Returns were stratified arbitrarily. All jaw tags returned before December 31 of the same stock year were considered first year returns, and tags returned from January 1 to December 31 the following year were considered second year returns. The difference in returns among the hatcheries was evaluated for the first year, second year, and the combined first and second year returns.

Total adjusted return-to-creel estimates were made for the 1999 and 2000 plants. A mean compliance rate was formulated from previous studies to adjust for noncompliance in reporting tags (Table 12). The adjusted return creel rate was calculated by dividing the tag return rate by the compliance rate. Since the true rate of non-reporting is unknown, we also calculated adjusted return to creel rates with a range of compliance estimates (Reiman 1987).

Table 11. Hatchery source, water, and number of tagged rainbow trout stocked into Idaho waters in 1999 and 2000.

		Tagged Fish Stocked				
Year	**Site**	**AF**	**Hag-R**	**Hag-T**	**Nampa**	**Total**
1999	Blair Trail Res.	200	200	198	200	798
	Cove Arm Res.	199	200	200	200	799
	Deep Cr. Res.	200	200	199	200	799
	Dierkes L.	196	199	200	199	794
	Dog Creek Res.	200	199	200	200	799
	Featherville P.	200	200	200	200	800
	Hawkins Res.	200	200	198	199	797
	Lava L.	200	200	200	199	799
	Little Camas Res.	200	200	200	200	800
	Magic Res.	200	200	200	200	800
	Mann Creek Res.	199	200	199	199	797
	Mt. Home Res.	198	200	198	200	796
	Park Center P.	200	200	198	199	797
	Roseworth Res.	199	200	200	199	798
	Sublett Res.	200	200	199	198	797
	U. Payette L.	200	200	200	200	800
	Total	**3,191**	**3,198**	**3,189**	**3,192**	**12,770**
2000	Blair Trail Res.	199	200		200	599
	Cove Arm Res.	200	200		200	600
	Deep Cr. Res.	200	200		200	600
	Dierkes L.	198	200		200	598
	Dog Creek Res.	200	200		200	600
	Featherville P.	—	—		200	600
	Hawkins Res.	200	200		200	600
	Horsethief Res.	200	198	No fish	209	607
	Lava L.	199	200	stocked	200	599
	Little Camas Res.	200	200		200	600
	Magic Res.	200	200		201	601
	Mann Creek Res.	—	—		200	600
	Mt. Home Res.	200	200		200	600
	Park Center P.	200	200		200	600
	Roseworth Res.	200	200		200	600
	Sublett Res.	200	200		200	600
	Total	**2,796**	**2,798**		**2,810**	**8,404**

The proportion of returned tags was statistically compared among hatcheries. Tag return data were adjusted for both transport-mortality and shed tags. Return data were standardized (# returned / # stocked) and arcsine transformed prior to the statistical analysis. Confidence bounds were assigned to the proportion of tags returned using methods described in Fleiss (1981). Tag returns among hatcheries were compared with a randomized blocked ANOVA ($\alpha = 0.05$) where tag return was the dependent variable and water and hatchery were the independent variables (Zar 1999, SYSTAT 1999). The null hypothesis for each return strata was $Nampa_R$ = $Hag\text{-}R_R$ = $Hag\text{-}T_R$ = American $Falls_R$, where $hatchery_R$ represents the proportion of tag returns from each hatchery. If the null hypothesis were rejected, the interaction among independent variables (study water X hatchery) was examined graphically (Neter et al. 1990). A Tukey's multiple comparison test was used to detect significant differences in returns among hatcheries. The level of influence the independent variables (hatchery and water) had on tag returns was described using one-way ANOVA. A combined model was not possible; therefore, the level of influence of hatchery and water were considered separately. Two study waters were removed from the 2000 analysis. An undetermined number of tagged trout destined for Mann Creek Reservoir and Featherville Dredge Pond escaped from the holding pens before stocking. The proportion of tagged trout returned from those study waters could not be determined.

Table 12. Band or tag reporting rates from previous studies. Estimated tag return reporting rates (compliance) are listed for standard (non-reward) tags.

Reference	Species	Incentive ($)	Estimated compliance (%)
Standard tag or band			
Nichols et al. 1991	Duck	None	32
Nichols et al. 1991 – adjusted for bias	Duck	None	26
Henry and Burnham 1976	Duck	None	38
Nichols et al. 1995	Duck	None	38
Conroy and Blandin 1984	Duck	None	43
Reeves 1979	Dove	None	38
Average			**36**

The relation between fish health and tag returns was investigated. Each raceway was evaluated separately, since fish health may be unique among raceways. An autopsy-based fish health assessment method (HCP) was used to characterize fish health prior to stocking (Goede and Barton 1990). Twenty trout per raceway were randomly collected from each raceway population and subsequently autopsied and evaluated by IDFG fish pathologists. Several raceways were evaluated at Nampa (n = 5), Hag-R (n = 3), Hag-T (n = 2), and American Falls (n = 4). The HCP procedure included the examination of 16 health-related criteria (Table 13). Data were compiled with AUSOM© software program (AUSOM© 1996). The AUSOM© program combines ten criteria to generate the normality index (NI), which reflects the overall health of the hatchery population sampled. Simple linear regression was used to determine if prestock fish health could predict post-stock tag returns. The average return rate (all waters stocked from the same raceway) was regressed against NI.

Basic water quality data were collected to examine the relation between water quality and hatchery specific returns. In mid-August, dissolved oxygen, water temperature, turbidity (Secchi disc), pH, and conductivity data were gathered for the study waters. Additionally, zooplankton samples were taken to characterize productivity at each water. Plankton were collected at two to three locations with three nets of varying mesh size (153, 500, 750 μ mesh). The plankton samples were processed and reported as described in Teuscher (1999). Data are presented in Table 6 and Appendix B. Simple linear regression was used to determine if the ZPR or ZQI index could be used to predict carryover of stocked catchable-rainbow trout.

Table 13. Criteria used to evaluate prestock fish health in 1999 and 2000 (AUSOM© 1996).

Parameter	Evaluation criteria	Data expression
General		
Length	Total length (mm)	Integer
Weight	Weight (g)	Integer
Ktl and Ctl	Ktl = (W * 10^5) / L^3 ; Ctl is converted from Ktl and expressed as Ctl times 10 to the fourth power	Integer
Autopsy		
Eyes	Normal, exopthalmia, hemorrhagic, blind missing, other	% Normal
Gills	Normal, frayed, clubbed, marginate, pale, other	% Normal
Pseudobranch	Normal, swollen, lithic, swollen & lithic, inflamed, other	% Normal
Thymus	No hemorrhage, mild hemorrhage, severe hemorrhage	% Normal
Fins	No active erosion or pervious erosion healed over, mild active erosion with no bleeding, severe active erosion with hemorrhage and / or secondary infection	% Normal
Opercules	No shortening, mild shortening, severe shortening	% Normal
Messentary fat	Internal body fat expressed with regard to amount present	1, 2, 3, or 4
Spleen	Black, red, granular, nodular, enlarged, other	% Normal
Hind gut	No inflammation, mild inflammation, severe inflammation	% Normal
Kidney	Normal, swollen, mottled, granular, urolithic, other	% Normal
Liver	Red, light red, fatty liver, nodules, focal discoloration, general discoloration, other	% Normal
Bile	Yellow: bladder empty or partially full, yellow: bladder full and distended, light green, dark green	Integer
Gender	Male or female	M, F (%)
Blood		
Hematocrit	Volume of red blood cells	% total volume
Leucocrit	Volume of white blood cells	% total volume
Plasma protein	Amount of plasma protein	g / 100 ml
Summary		
Normality index	This index is calculated by averaging the “% Normals”	Percent
Severity index	This index is calculated by averaging the specific percent indices for the thymus, gut, fin, and opercule	Percent
Feeding index	This index is calculated by subtracting the “bile index” from 100	Percent

RESULTS

The first year performance of trout varied among hatcheries. First year returns were not equal among hatcheries in 1999 ($F_{0.05(1),3,45}$ = 6.45, P <0.001) or in 2000 ($F_{0.05(1),2,26}$ = 14.91, P <0.0005). The relative performance of trout from each hatchery was inconsistent between 1999 and 2000 (Table 14). In 1999, Nampa trout returned at the highest rate (15.4%), followed by American Falls (14.5%), Hag-T (12.1%) and Hag-R (11.2%). In 2000, American Falls trout returned at the highest rate (18.6%), followed by Hag-R (12.2%) and Nampa (11.1%). American Falls first year returns showed a 52% and 68% increase relative to Nampa and Hag-R. In 1999, returns were lowest from Hag-R and Hag-T stocked trout, whereas the lowest returns in 2000 were from Nampa. Specific significant differences among hatcheries are described in Table 15.

Overall returns differed among hatcheries. Tags returned between the stock date in 1999 and December 31, 2000 were unequal among hatcheries ($F_{0.05(1),3,45}$ = 11.02, P <0.001). The combined first and second year returns were similar for American Falls (18.9%) and Nampa (17.5%), both of which differed from Hag-T (13.7%) and Hag-R (12.5%) (Table 14). The higher carryover returns from American Falls trout affected the overall performance ranking and resulted in American Falls trout slightly outperforming Nampa. Tags returned between the stock date in 2000 and December 31, 2001 were also unequal among hatcheries ($F_{0.05(1),2,26}$ = 20.3, P < 0.01) The return rate from Nampa (12.8%) and Hagerman Riley Creek (13.8%) were similar, but both were substantially lower than American Falls (21%). Carryover rate had little effect on the overall performance ranking in 2000.

Carryover of trout stocked in 1999 was unequal among hatcheries; however, carryover of trout stocked in 2000 was equal. Returns of trout stocked in 1999 and returned in 2000 (i.e., carryover) differed significantly ($F_{0.05(1),3,45}$ = 11.40, P <0.001). On average, <3% of all trout stocked in 1999 were returned in the second year. Second year returns ranged from 1.3-4.5%, with trout from American Falls providing two to three times the carryover returns of the other three hatcheries (Table 14). Overall return rate of trout stocked in 2000 and returned through December 2001 was low (<1%) and not different among hatcheries ($F_{0.05(1),2,26}$ =2.50, P = 0.11). The carryover rate ranged from 0.6-1.1% with the return rate from American Falls slightly exceeding Nampa and Hagerman (Riley Creek).

There was a wide range of returns among hatcheries within waters. The range in first year return from the 1999 plant was greatest among hatcheries in Roseworth Reservoir (14.6%), Sublett Reservoir (10.2%), and Dierkes Lake (10.1%) (Table 11). Returns were most similar (i.e., small range) in Featherville Dredge Pond (4.0%), Dog Creek Reservoir (4.0%), and Park Center Pond (3.5%). The variation in returns among hatcheries within waters was not consistent between the 1999 and 2000 plants. First year returns from the 2000 plant were most different among hatcheries in Roseworth Reservoir (18.0%), Park Center Pond (13.5%), and Dog Creek Reservoir (13.5%), whereas the returns were most similar among hatcheries in Dierkes Lake (5.7%), Cove Arm Reservoir (2.0%), and Lava Lake (1.1%).

Most of the variation in tag returns can be explained by water-specific influences. ANOVA models including both the 1999 and 2000 plants showed 66-77% of the variation in the performance of stocked rainbow trout was the result of site-specific influences (Table 16). The first year and overall returns from the 1999 plant were independent from hatchery influences; however, carryover from the 1999 plant was significantly impacted by hatchery influences. When significant, hatchery influences upon the returns were relatively small (13-21%) when compared to water-specific influences. Variation in the first year return from the 2000 plant was significantly related to both hatchery and site influences.

Assuming that the compliance rate for 1999 and 2000 was similar to what has been reported in the literature (36%), adjusted return-to-creel estimates ranged from 15-75% in the 16 waters stocked in 1999 and from 19-77% in the 14 waters stocked in 2000 (Table 17). Of the waters stocked in 1999, 44% met the goal of 40% return by number (IDFG 2001), whereas 50% of the waters stocked in 2000 met this goal. Returns were inconsistent between the stocking years. Adjusted return-to-creel was highest in Hawkins and Roseworth reservoirs for the water stocked in 1999. For the water stocked in 2000, Park Center Pond (73%) and Horsethief Reservoir (55%) had the highest return rate. Only Hawkins, Roseworth, Deep Creek, and Little Camas Reservoirs met the return goal in both years. Dog Creek, Cove Arm, and Magic Reservoirs, as well as Lava and Dierkes lakes, did not meet the stocking goal in either year. All other waters were inconsistent between years. The adjusted return rate decreased between 1999 and 2000 by 20% or greater in Hawkins, Roseworth, Sublett, and Magic Reservoirs. In contrast, there was only one large increase (44%) in adjusted return rate between years, which occurred at Park Center Pond.

There was no relation between prestock fish health and post-stock returns. Results of the HCP analysis are presented in Table 18. The normality index derived from the HCP evaluation was not a good predictor of returns (n = 7, R^2 = 0.00, P = 0.96). Healthier fish measured by HCP showed no advantage over less healthy fish in returns.

There was no statistical relationship between water productivity (ZPR) and carryover returns. The carryover rate of trout stocked in 1999 and 2000 showed no relationship to the abundance of large zooplankton in August (n = 14, R^2 = 0.01, P = 0.78).

The rate and timing of tag returns varied among hatcheries. Generally, in both the 1999 and 2000 plants, the majority of the tagged trout were caught within the first 100 days after stocking (DAS) (Figure 9). The timing of tag returns was not consistent between the 1999 and 2000 plants. More tags were returned from Nampa Hatchery in the first 100 DAS in 1999 than Hag-R, Hag-T, and American Falls hatcheries. However, in 2000, the trends were reversed and relatively few tags were returned from Nampa Hatchery in the same time period. Additionally, the double pulse of returns found within the first 200 DAS in 1999 was not present in 2000.

The average size of stocked trout in 2000 varied among hatcheries. Mean lengths stocked were 268 mm (SE = 0.8), 259 mm (SE = 0.8), and 243 mm (SE = 0.8) for American Falls, Hag-R, and Nampa hatcheries, respectively (Figure 10). Fish size differed significantly among hatcheries (F = 224.8; df = 2, 2097; P <0.01), but the maximum difference among hatcheries was small (2.5 cm). The statistical test was highly sensitive and would have determined a significant difference if mean lengths differed by even 1 mm (effect size <1 mm).

DISCUSSION

Given the two years of stocking, results indicate the relative return of trout was not consistent among the hatcheries examined with respect to the first year returns, second year returns, and the overall returns. The disparity of returns among hatcheries suggests the hatchery environment may have affected the performance of stocked trout; however, the performance was inconsistent. For example, trout stocked from Nampa were returned at the highest rates in the first year following the 1999 plant, whereas in 2000, American Falls showed substantially better returns. This fact suggests the hatchery environment does affect post-stock performance, but the specific hatchery influence is not identified with this experimental design. Generally, American Falls produced trout that provided relatively high first year returns and exceptionally high carryover. Nampa trout performed well in 1999 but relatively poorly in 2000. Hagerman trout consistently provided 11-12% returns, which on average is lower than the other hatcheries. However, trout stocked from Hagerman Hatchery outperformed Nampa Hatchery on average in 2000. The past impression held by some IDFG personnel that Hagerman product is consistently inferior is not correct based on the present study.

Table 14. Return rate (%) of trout stocked into Idaho waters in 1999 and 2000 from American Falls, Hagerman-Riley, Hagerman-Tucker, and Nampa hatcheries.

	AF			Hag-R			Hag-T			Nampa			Total		
Site	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both	Yr 1	Yr 2	Both
Fish tagged and stocked in 1999															
Hawkins Res.	22.5	6.0	**28.5**	21.0	1.5	**22.5**	29.8	1.0	**30.8**	24.1	2.0	**26.1**	24.3	2.6	**27.0**
Roseworth Res.	20.1	11.1	**31.2**	16.5	4.5	**21.0**	14.0	2.5	**16.5**	28.6	4.0	**32.7**	19.8	5.5	**25.3**
Deep Cr. Res.	23.0	5.5	**28.5**	17.5	2.0	**19.5**	17.1	5.5	**22.6**	17.0	3.5	**20.5**	18.6	4.1	**22.8**
Featherville P.	22.5	1.0	**23.5**	19.0	0.5	**19.5**	21.0	0.0	**21.0**	23.0	0.5	**23.5**	21.4	0.5	**21.9**
Little Camas Res.	15.5	7.5	**23.0**	9.0	5.0	**14.0**	14.0	4.5	**18.5**	17.5	3.0	**20.5**	14.0	5.0	**19.0**
Sublett Res.	18.5	2.0	**20.5**	12.0	0.0	**12.0**	17.6	0.0	**17.6**	22.2	0.0	**22.2**	17.6	0.5	**18.1**
Mt. Home Res.	17.7	9.1	**26.8**	11.5	1.0	**12.5**	9.1	0.0	**9.1**	14.0	2.0	**16.0**	13.1	3.0	**16.1**
Magic Res.	12.0	13.5	**25.5**	5.5	2.0	**7.5**	7.0	3.5	**10.5**	8.5	4.0	**12.5**	8.3	5.8	**14.0**
Mann Cr. Res.	11.1	5.5	**16.6**	7.0	2.0	**9.0**	8.0	1.0	**9.0**	17.1	4.0	**21.1**	10.8	3.1	**13.9**
Blair Trail Res.	14.5	0.0	**14.5**	11.5	0.0	**11.5**	10.6	0.0	**10.6**	17.5	0.5	**18.0**	13.5	0.1	**13.7**
Dierkes L.	8.2	2.0	**10.2**	11.6	0.5	**12.1**	14.0	0.5	**14.5**	17.1	1.0	**18.1**	12.7	1.0	**13.7**
Park Center P.	11.0	0.5	**11.5**	12.5	0.0	**12.5**	10.6	0.5	**11.1**	14.1	0.0	**14.1**	12.0	0.3	**12.3**
Cove Arm Res.	10.1	7.0	**17.1**	5.0	2.5	**7.5**	6.0	5.0	**11.0**	4.0	8.0	**12.0**	6.3	5.6	**11.9**
Lava L.	10.5	1.0	**11.5**	7.5	0.0	**7.5**	6.5	0.0	**6.5**	11.1	1.0	**12.1**	8.9	0.5	**9.4**
Dog Creek Res.	5.5	0.0	**5.5**	6.5	0.0	**6.5**	4.5	1.0	**5.5**	8.5	0.0	**8.5**	6.3	0.3	**6.5**
U. Payette L.	10.0	0.0	**10.0**	5.5	0.0	**5.5**	4.0	0.0	**4.0**	2.0	0.0	**2.0**	5.4	0.0	**5.4**
Total	14.5	4.5	**18.9**	11.2	1.3	**12.5**	12.1	1.6	**13.7**	15.4	2.1	**17.5**	13.3	2.4	**15.3**
95% LCL	13.3	3.8	**17.0**	10.1	0.9	**11.0**	11.0	1.1	12.2	14.1	1.6	**16.0**	12.7	2.1	**14.7**
95% UCL	15.8	5.2	**19.8**	12.3	1.8	**13.4**	13.3	2.0	14.6	16.7	2.6	**18.7**	13.9	2.6	**16.0**
Fish tagged and stocked in 2000															
Park Center P.	35.5	0.0	**35.5**	25.5	0.0	**25.5**				22.0	0.0	**22.0**	27.7	0.0	**27.7**
Horsethief Res.	32.0	2.0	**34.0**	21.0	3.0	**24.2**				19.1	2.9	**22.0**	24.1	2.6	**26.7**
Little Camas Res.	25.5	2.0	**27.5**	17.5	0.5	**18.0**				19.0	0.5	**19.5**	20.7	1.0	**21.7**
Hawkins Res.	23.5	1.5	**25.0**	11.5	0.0	**11.5**				15.5	0.0	**15.5**	16.8	0.5	**17.3**
Roseworth Res.	25.5	3.0	**28.5**	10.0	1.5	**11.5**				8.5	2.5	**11.0**	14.7	2.3	**17.0**
Dog Creek Res.	20.0	0.0	**20.0**	13.0	0.0	**13.0**				6.5	0.0	**6.5**	13.2	0.0	**13.2**
Dierkes L.	16.5	0.0	**16.7**	11.5	0.5	**12.0**				11.0	0.0	**11.0**	13.1	0.2	**13.2**
Blair Trail Res.	13.5	0.0	**13.6**	22.5	0.0	**22.5**				16.0	0.0	**16.0**	17.4	0.0	**17.4**
Deep Cr. Res.	24.5	3.5	**28.0**	17.0	3.0	**20.0**				19.0	0.0	**19.0**	20.2	2.2	**22.3**
Mt. Home Res.	16.0	1.5	**17.5**	8.0	0.0	**8.0**				6.5	0.5	**7.0**	10.2	0.7	**10.8**
Lava L.	10.5	0.0	**10.6**	9.5	0.0	**9.5**				9.5	0.0	**9.5**	9.9	0.0	**9.9**
Cove Arm Res.	9.0	1.0	**10.0**	7.0	0.5	**7.5**				9.5	1.5	**11.0**	8.5	1.0	**9.5**
Sublett Res.	14.0	1.0	**15.0**	6.0	0.0	**6.0**				3.5	0.0	**3.5**	7.8	0.3	**8.2**
Magic Res.	11.5	0.5	**12.0**	2.0	1.5	**3.5**				5.0	0.5	**5.5**	6.2	0.8	**7.0**
Featherville P.[a]	-na-	-na-	**-na-**	-na-	-na-	**-na-**				-na-	-na-	**-na-**	-na-	-na-	**-na-**
Mann Cr. Res.[a]	-na-	-na-	**-na-**	-na-	-na-	**-na-**				-na-	-na-	**-na-**	-na-	-na-	**-na-**
Total	19.9	1.1	**21.0**	13.0	0.8	**13.8**				12.2	0.6	**12.8**	15.0	0.8	**15.9**
95% LCL	18.4	0.8	**19.5**	11.8	0.5	**12.5**				11.0	0.3	**11.6**	14.3	0.7	**15.1**
95% UCL	21.4	1.6	**22.6**	14.3	1.2	**15.1**		No Fish Available		13.5	0.9	**14.1**	15.8	1.1	**16.7**

[a] Return rates of stocked fish could not be determined due to escape of tagged trout prior to stocking.

Table 15. Results (P values) from a Tukey's multiple comparison test comparing tag returns among hatcheries. Significant difference (α = 0.05) is denoted with an asterisk (*****).

					Hatchery			
Stock year	**Returns**	**MSE**	**df**	**Hatchery**	**AF**	**Hag-R**	**Hag-T**	**Nampa**
1999	Year 1[a]	0.002	45	AF	1.00			
				Hag-R	0.02*	1.00		
				Hag-T	0.06	0.97	1.00	
				Nampa	0.99	0.01*	0.03*	1.00
	Year 1[b]	0.002	45	AF	1.000			
				Hag-R	0.091	1.000		
				Hag-T	0.023*	0.937	1.000	
				Nampa	0.974	0.034*	0.007*	1.000
	Year 2	0.003	45	AF	1.000			
				Hag-R	0.000*	1.000		
				Hag-T	0.000*	0.989	1.000	
				Nampa	0.006*	0.499	0.321	1.000
	Year 1&2	0.003	45	AF	1.000			
				Hag-R	0.001*	1.000		
				Hag-T	0.000*	0.882	1.000	
				Nampa	0.636	0.023*	0.003*	1.000
2000	Year 1	0.003	26	AF	1.000			
				Hag-R	0.001*	1.000		
				Hag-T	NA	NA	NA	
				Nampa	0.000*	0.847	NA	1.000
	Year 1[b]		26	AF	1.000			
				Hag-R	0.000*	1.000		
				Hag-T	NA	NA	NA	
				Nampa	0.000*	0.822	NA	1.000
	Year 2		26	AF	1.000			
				Hag-R	0.319	1.000		
				Hag-T	NA	NA	NA	
				Nampa	0.123	0.841	NA	1.000
	Year 1&2		26	AF	1.000			
				Hag-R	0.000*	1.000		
				Hag-T	NA	NA	NA	
				Nampa	0.000*	0.763	NA	1.000

[a] Data from Megargle 2000 that reported only tagged fish caught and reported by December 31, 1999.
[b] Corrected returns: tagged fish caught in 1999 and reported by December 31, 2000 were added (Megargle 2000).

Table 16. R square and significance from a one-way ANOVA that examined the variation of tag returns as explained by independent variables. Significance (α = 0.05) is denoted with an asterisk (*).

Year	Time Period	Independent Variable	R square	P
1999	1st year	Site	0.77	0.000*
		Hatchery	0.06	0.266
	2nd year	Site	0.70	0.000*
		Hatchery	0.13	0.038*
	1st and 2nd year	Site	0.71	0.000*
		Hatchery	0.12	0.048
2000	1st year	Site	0.67	0.000*
		Hatchery	0.20	0.013*
	2nd year	Site	0.69	0.000*
		Hatchery	0.05	0.400
	1st and 2nd year	Site	0.66	0.000*
		Hatchery	0.21	0.010*

The differential returns among hatcheries could result in lower quality fisheries in some locations. The hatchery source likely impacts angler success, and therefore, the efficiency of the put-and-take program. For example, if the first year return rates of the 2000 plants were applied to a water receiving 20,000 catchable trout, returns could range from 2,600 (Hag-R = 13.0%) to 3,780 (American Falls = 18.9%) trout depending upon the hatchery source. The same consideration may be applied to fingerlings if similar performance differences can be applied to the 1.3 million fingerlings reared at Hagerman. Because fingerlings must rear longer in the wild prior to capture by anglers, the potential for magnification of return reductions would seem more probable, if not likely. American Falls trout proved to generally outperform Nampa and Hagerman trout, and if feasible, anglers would benefit if all catchables were provided from American Falls. However, due to production and logistical limitations, that is obviously not an option. Additionally, the inconsistent differences among years limits any predictions as to which hatchery would provide a reliable advantage.

The cause of the discrepancy in catchable returns among hatcheries is unknown. Past research has linked the hatchery environment to post-stock survival, behavior, or the combination (Ginetz and Larkin 1976; Forgerlund et al 1981; Olla and Davis 1989; Ryer and Olla 1991, 1992, 1995a, 1995b; Olla et al. 1995, 1998). Since a fish's hatchery environment is often inconsistent during production, identifying the exact cause would be difficult without directly manipulating the hatchery environment in a controlled evaluation. Additionally, the causative agent may be a combination of influences that may not be apparent; however, some generalizations may be made.

Table 17. First year tag returns, return rate, and adjusted return to creel rate of jaw tagged rainbow trout stocked into Idaho waters in 1999 and 2000. Adjusted return to creel rate is estimated with varying levels of compliance.

Year	Water	Stock	Return-to-creel (tags)	Return-to-creel (%)	95% CI	Adjusted Return to Creel Rate (%) C=0.3	C=0.36	C=0.5
1999	Hawkins Res.	797	214	27	(24-30)	90	75	54
	Roseworth Res.	798	202	25	(22-29)	83	69	50
	Deep Cr. Res.	799	181	23	(20-26)	76	63	46
	Featherville P.	800	175	22	(19-25)	73	61	44
	Little Camas Res.	800	152	19	(16-22)	63	53	38
	Sublett Res.	797	144	18	(15-21)	60	50	36
	Mt. Home Res.	796	128	16	(14-19)	54	45	32
	Magic Res.	800	113	14	(12-17)	47	39	28
	Mann Cr. Res.	797	111	14	(12-17)	46	39	28
	Blair Trail Res.	798	109	14	(11-16)	46	38	27
	Dierkes L.	794	109	14	(11-16)	46	38	27
	Park Center P.	797	98	12	(10-15)	41	34	25
	Cove Arm Res.	799	95	12	(10-14)	40	33	24
	Lava L.	799	75	9	(8-12)	31	26	19
	Dog Creek Res.	799	53	7	(5-9)	22	18	13
	U. Payette L.	800	43	5	(4-7)	18	15	11
	Total	**12,770**	**2,002**	**16**	**(15-16)**	**52**	**44**	**31**
2000	Park Center P.	600	166	28	(24-31)	92	77	55
	Horsethief Res.	607	162	27	(23-30)	89	74	53
	Deep Cr. Res.	600	134	22	(19-26)	74	62	45
	Little Camas Res.	600	130	22	(18-25)	72	60	43
	Blair Trail Res.	599	104	17	(14-21)	58	48	35
	Hawkins Res.	600	104	17	(14-21)	58	48	35
	Roseworth Res.	600	102	17	(14-20)	57	47	34
	Dog Creek Res.	600	79	13	(11-16)	44	37	26
	Dierkes L.	598	79	13	(11-16)	44	37	26
	Mt. Home Res.	600	65	11	(9-14)	36	30	22
	Lava L.	599	59	10	(8-13)	33	28	20
	Cove Arm Res.	600	57	10	(7-12)	32	26	19
	Sublett Res.	600	49	8	(6-11)	27	23	16
	Magic Res.	601	42	7	(5-9)	23	19	14
	Total	**8,404**	**1,332**	**16**	**(15-17)**	**53**	**44**	**32**

It is possible but unlikely that return-to-creel differences among the hatchery may have been biased by transport vehicle and fish size disparity. Although efforts were made to standardize the stocking protocol among the hatcheries examined, some differences were apparent. In both 1999 and 2000, the average size of fish stocked differed by about 2 cm among hatcheries. The size discrepancy was slightly larger within some waters. However, Teuscher (1999) showed similar returns from trout that differed by 5 cm in length, and it is unlikely the small difference in length in this study substantially impacted returns. American Falls and Nampa hatcheries were able to use one-ton fish transport trucks, but Hagerman fish (Hag-T and Hag-R) were hauled in a dual compartment, two-ton transport. It would have been preferred that each hatchery planted trout with similar transports; however, fish transport densities among the hatcheries were similar. It was more important that the fish were held in the transport for equal periods prior to stocking.

Table 18. Fish health evaluation results of fish sampled from each of the three hatcheries examined in 2000. Data are summarized by raceway.

	Nampa[a]			Riley[b]			American Falls[c]	
	C2	**C3**	**C4**	**18**	**20**	**22**	**12**	**14**
TL (mm)	225.0	230.0	226.0	233.0	247.0	261.0	263.0	266.0
CV (%)	10.1	7.5	7.4	8.2	11.2	8.0	5.8	5.4
Weight (g)	146.0	152.0	141.0	155.0	194.0	216.0	231.0	245.0
CV (%)	28.8	30.1	25.2	28.8	33.6	29.9	17.9	20.1
Ktl	1.2	1.2	1.2	0.8	1.3	1.2	1.3	1.3
CV (%)	6.5	8.9	6.7	6.7	11.4	10.0	8.0	8.8
Ctl	4.5	4.4	4.3	3.0	4.5	4.3	4.6	4.6
Hematocrit	46.3	43.3	38.5	36.8	38.2	32.0	48.5	43.1
CV (%)	13.4	11.7	9.5	12.6	13.3	11.9	13.6	11.8
Leucocrit	1.8	1.4	1.4	2.1	1.6	1.4	1.5	1.6
CV (%)	35.2	42.7	36.2	51.2	37.4	43.5	47.3	51.3
Plasma protein	6.5	6.9	6.1	7.0	6.6	6.1	6.6	6.3
CV (%)	11.1	9.5	10.8	5.5	10.3	9.8	15.5	23.7
Eyes	95.0	95.0	100.0	95.0	100.0	100.0	100.0	100.0
Gills	65.0	80.0	70.0	5.0	15.0	10.0	85.0	100.0
Pseudobranch	95.0	95.0	100.0	90.0	85.0	85.0	100.0	100.0
Thymus	75.0	50.0	80.0	100.0	85.0	80.0	35.0	45.0
Messentary fat	3.2	3.8	2.5	2.1	2.3	2.0	3.7	3.8
Spleen	100.0	100.0	100.0	100.0	90.0	95.0	100.0	95.0
Hind gut	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Kidney	100.0	100.0	100.0	95.0	95.0	100.0	100.0	100.0
Liver	95.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Bile	1.0	1.0	1.0	0.2	0.2	0.8	1.0	2.0
Fin	75.0	40.0	50.0	90.0	70.0	70.0	40.0	30.0
Opercule	100.0	95.0	85.0	90.0	95.0	95.0	100.0	100.0
Percent female	100.0	100.0	100.0	100.0	100.0	100.0	95.0	100.0
Percent male	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0
Normality index[d]	90.0	85.5	88.5	86.5	83.5	83.5	86.0	87.0
Severity index[e]	9.4	18.8	13.8	2.5	21.3	8.1	21.3	24.4
Feeding index[f]	66.7	66.7	66.7	95.0	95.0	73.3	66.7	33.3

[a] Raceway C3: Coldwater disease - Flavobacterium psychrophilum (1/12-carrier)
Bacteremia - Pasteurella sp. (1/12-carrier)
[b] Raceway 18: MAS - Aeromonas caviae (1/12-carrier)
Raceway 20: Pseudomonas – Pseudomonas mallei (3/12-carrier)
[c] Raceway 12: Coldwater Disease - Flavobacterium psychrophilum (1/12-carrier)
Raceway 14: Coldwater Disease - Flavobacterium psychrophilum (1/12-carrier)
[d] Average of the "percent normals" excluding bile and messentary fat; expressed as percent
[e] Average of the "percent normals" including thymus, gut, fin, and opercule; expressed as percent
[f] Calculated by subtracting the bile index from 100; expressed as percent

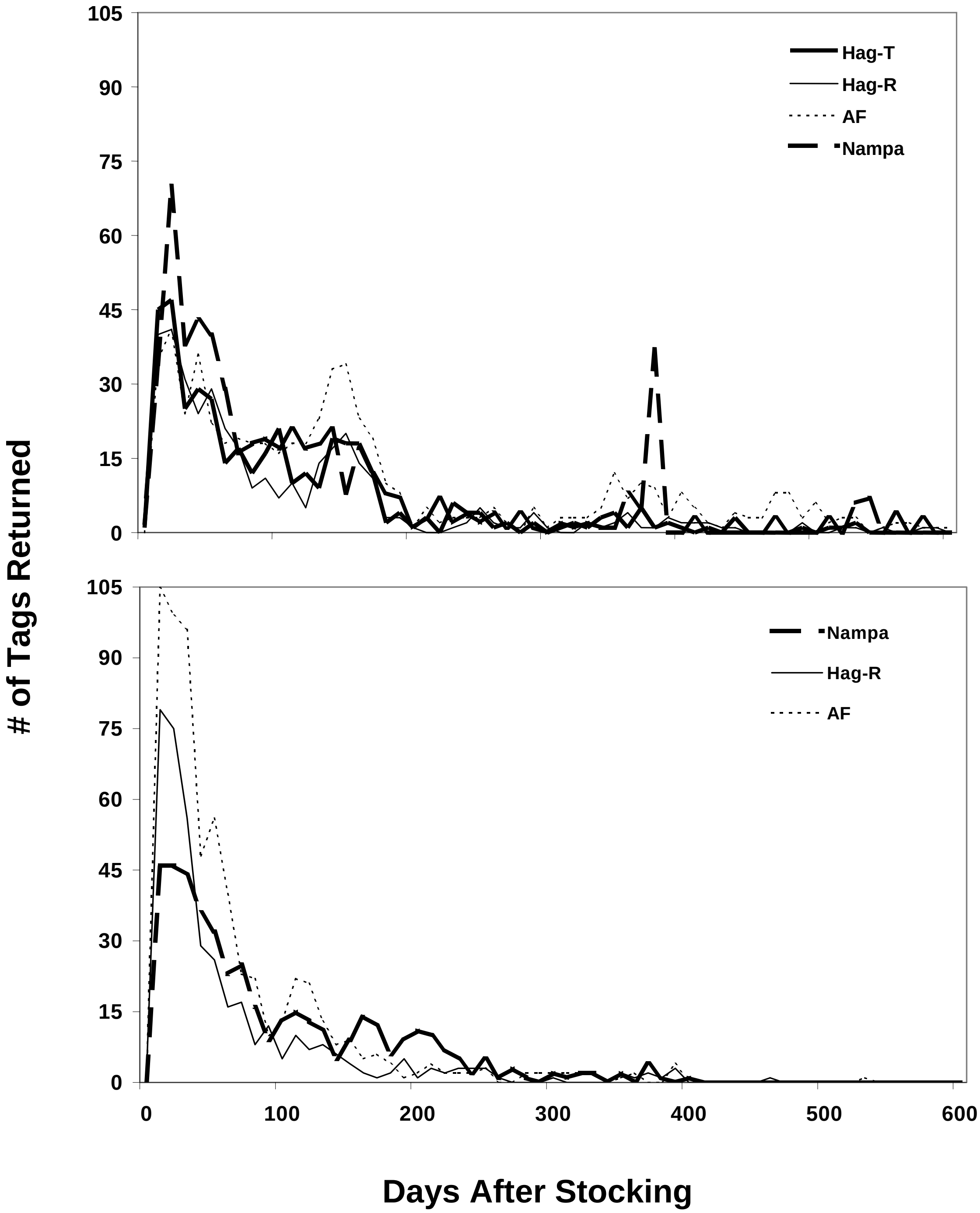

Figure 8. The timing of returns of tagged fish stocked throughout southern Idaho in 1999 (upper graph) and 2000 (lower graph) from Nampa, Hag-R, Hag-T, and American Falls hatcheries.

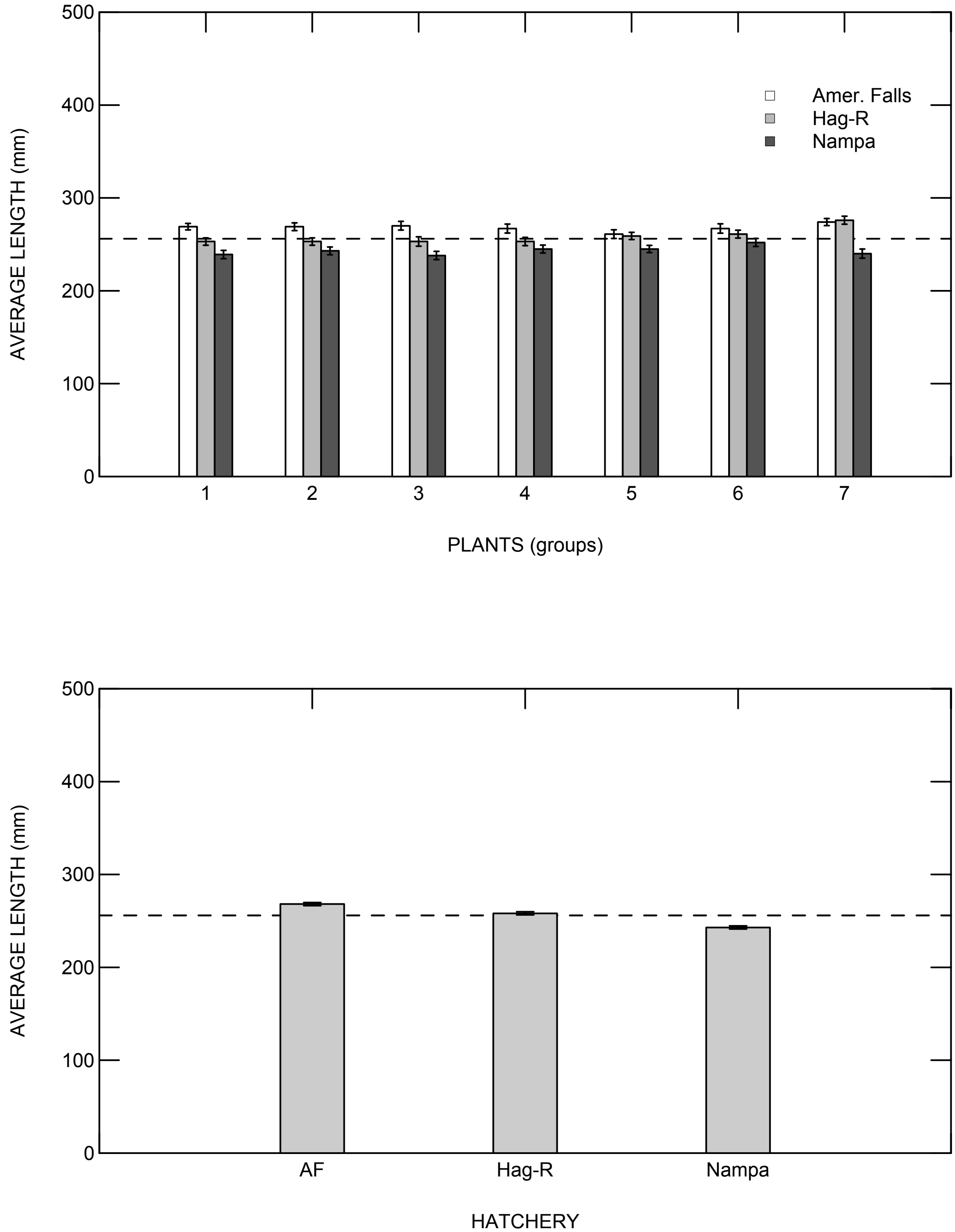

Figure 9. Mean length by hatchery (lower graph) and plant group (upper graph) of trout stocked in 14 lakes and reservoirs by American Falls, Hagerman-Riley (Hag-R), and Nampa hatcheries in 2000. Stock groups are defined in Table 7. Dashed line represents average length of all stocked trout combined.

Rearing densities and the amount of handling prior to stocking were different among the hatcheries examined. American Falls produce trout at considerably lower densities than either Nampa or Hagerman. It is not unusual for trout to exceed density index levels of 0.5 several times throughout production in Nampa and Hagerman; however, at American Falls density index levels rarely exceed 0.2 except just prior to stocking (<0.4). In addition to reduced densities, fish are handled or moved less at American Falls than at the other hatcheries. Fish are handled (moved) three to four times at Hagerman, one or two times at Nampa and once at American Falls. Low densities and reduced handling likely minimize chronic stress levels as evidenced by reduced disease outbreaks. Forgerlund et al. (1981) reported decreased growth and condition, reduced conversion, and increased stress and mortality of salmonids reared at high densities. It may be suggested that a reduction in production and prestock handling might improve returns from Hagerman hatchery, but the 52-68% potential increase in returns may not compensate for lost overall production. Rearing densities at American Falls Hatchery were approximately one third of those at Hagerman and Nampa, which would suggest that nearly a two-thirds reduction in production would be needed to achieve the potential increase in returns. Chronic stress loads of catchable trout would likely be reduced with any reduction in production, thus improving fish health and reducing disease outbreaks (Patino et al. 1986). In addition, a substantial reduction in production would mean a substantial reduction in overall hatchery expenses. A controlled experiment comparing the return-to-creel of trout reared at current and greatly reduced densities at either Hagerman or Nampa hatchery would be useful to further explore the benefits of low density rearing.

Prestock fish health was unrelated to post-stock returns. A regression model produced a poor fit, neutral-sloped model. In some cases, fish with higher normality index ratings were found to have lower return rates. American Falls and Nampa hatcheries produced trout of similar health according to the HCP evaluation; however, their returns were significantly different. These results suggest that prestock fish health screening would not provide any insight as to the expected performance of hatchery trout. There may be several reasons why no statistical relation could be found. First, the normality index values measured at all hatcheries in 1999 and 2000 were never lower than 83%. Perhaps if a greater range in normality index were evaluated (i.e., extremely low values), a better-fit model would be possible. Second, fish were stocked into a wide variety of waters that differed in productivity, thermal and oxygen refugia, depth, and angling pressure (as evidenced by return rates). The heavy influence of the natural environment may have biased, or at least diluted, any potential relationship. Regardless, the use of the HCP evaluation as a predictive management tool does not seem to show promise. Obvious critical health concerns (i.e. symptomatic disease outbreaks) will undoubtedly impact post-stock survival, but the importance of the subtle health differences detected by the HCP evaluation were not shown to be a significant factor in return-to-creel.

Most of the overall tag return variation was due to water-to-water variation; a smaller portion was attributed to hatchery-specific influences. After examining the relation between water, hatchery, and returns, it was obvious that where the fish were stocked exerted greater influence on tag returns than did the hatchery source. In fact, overall returns of the 1999 plant were not significantly influenced by the hatchery source. Overall statewide returns could be better enhanced and stabilized by a reduction (or elimination) of stocking in waters that provide poor fisheries than if the return potential was improved at Hagerman Hatchery. The results of this study emphasize the need to evaluate stocking waters regularly, especially in light of a reduced hatchery budget, and adjust stocking requests accordingly.

Carryover returns of catchable trout were very low, <3% in 1999 and <1% in 2000, and were unrelated to the relative abundance of large zooplankton during late summer (ZPR).

Plankton productivity and fingerling survival has been shown to have a positive relation, because plankton were likely a major portion of their forage (Teuscher 1999). Catchable size trout switch to a diet composed primarily of aquatic macroinvertebrates and fish (Dillon 1992). Therefore, it is not surprising that estimates of the abundance of large zooplankton did not improve our ability to estimate the carryover potential of catchable trout. However, ZPR is a good indicator of water productivity, and highly productive waters probably provide a survival advantage to catchable trout. Other factors such as emigration, predation, or water quality may have obscured this relationship.

Adjusted return-to-creel estimates suggest that 44% and 50% of the stocking locations for the 1999 and 2000 stocking events met minimum harvest goals. These estimates were based on a mean compliance estimate, which was compiled from the literature. We were unable to report a confidence limit with this approach, but instead reported adjusted return to creel estimates using a range of plausible compliance rates. The majority of the tag reporting or compliance studies found in the literature have focused on the reporting rate for banded mallards *Anas platyrhynchos* during the 1970s and 1980s. These studies suggest that reporting rates are dependent on the monetary value of a tag, distance to a fish and wildlife agency office, relative abundance of tags in the population, and visibility of fish and wildlife personnel, and that rates changes through time. Almost no literature may be found on the return rate for jaw tagged fish, which is unfortunate as these reporting rates are important for management decisions. For instance, if our compliance rate equaled 50% instead of 36%, the percentage of stocking locations that met stocking goals would have dropped to 25% and 29% for the 1999 and 2000 stocking events. Conversely, if compliance were actually lower than 36%, nearly all stocking locations would meet stocking goals. If angler reported tags are to be used for future research projects or management decisions, it is important that factors affecting the reporting rate of jaw tagged fish in Idaho be identified and that reporting rates be estimated.

Extremely low returns were likely caused by drought conditions, and low harvest was expected. It is important to note that harvest estimates in this report do not reflect season-long estimates and should be considered accordingly. In some instances, trout were stocked outside of the normal schedule as determined by regional fish managers, and more harvest would likely have resulted with increased angling effort. The addition of second year returns did not substantially increase the number of waters reaching the 40% goal. Additionally, further efforts should be made to evaluate return-to-creel by weight.

In conclusion, we found significant differences in the return-to-creel of catchable trout stocked from American Falls, Nampa, and Hagerman hatcheries. There is evidence that the source of rainbow trout catchables can impact the post-stock performance of the trout. However, the hatchery specific post-stock performance was not predictable or consistent between years or among stocking waters. An explanation for this inconsistent performance was not determined. Generally, American Falls trout performed best, followed by Nampa and Hagerman. Prestock fish health, as measured using the HCP examination, does not appear to be a useful management tool when evaluating the return-to-creel. The relationship between carryover and ZPR may yet prove to be a useful management tool to understand carryover potential of stocking waters.

MANAGEMENT RECOMMENDATIONS

1. If future budgets required a significant reduction in CRBT stocking, reduction of production at Hagerman would appear to have the least impact on Idaho anglers.

2. Do not use the HCP evaluation as a management tool to predict the return-to-creel of catchable rainbow trout.

3. Do not use the ZPR evaluation as a management tool to predict the carryover potential of catchable rainbow trout

4. Determine factors that affect tag reporting rate of fish in Idaho.

5. Conduct a controlled study at Hagerman or Nampa to evaluate how a density reduction at those facilities may impact the post-stock returns of catchable trout.

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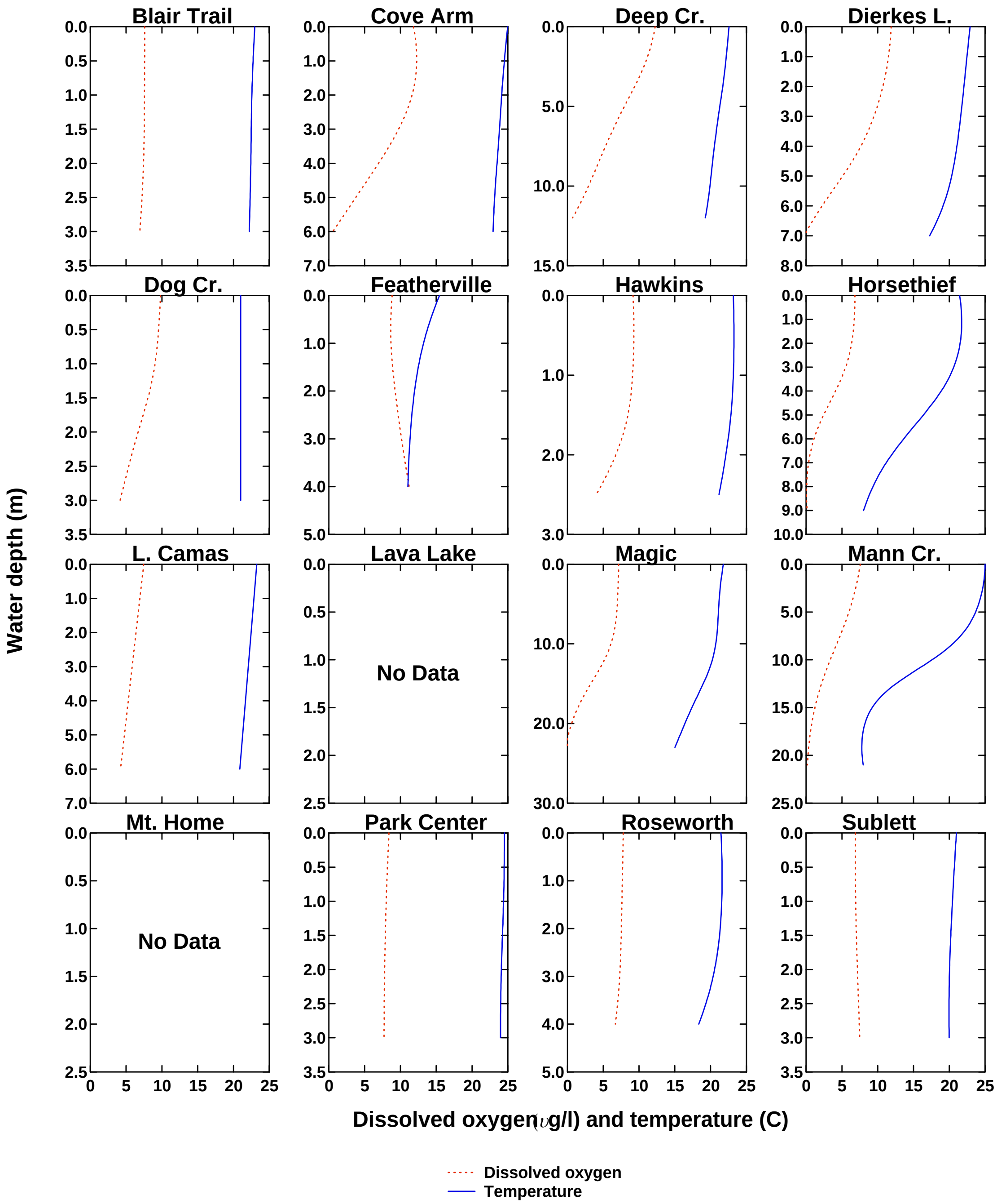
APPENDICES

Appendix A. Temperature and dissolved oxygen profiles for each of the study waters stocked in August 2000.



Appendix B. Tag numbers, hatchery source, water, and stock date of tagged trout stocked in south-central Idaho in 1999 and 2000.

Year	Tag Series[a]	Hatchery	Water	Date
1999	00001 - 00200	American Falls	Mountain Home Reservoir	May 19, 1999
	00201 - 00400	American Falls	Lava Lake	May 17, 1999
	00401 - 00600	American Falls	Dierkes Lake	May 18, 1999
	00601 - 00800	American Falls	Dog Creek Reservoir	May 20, 1999
	00801 - 01000	American Falls	Park Center Pond	May 21, 1999
	01001 - 01200	American Falls	Sublett Reservoir	May 24, 1999
	01201 - 01400	American Falls	Blair Trail Reservoir	May 25, 1999
	01401 - 01600	American Falls	Cove Arm Reservoir	May 26, 1999
	01601 - 01800	American Falls	Deep Creek Reservoir	May 27, 1999
	01801 - 02000	American Falls	Roseworth Reservoir	June 2, 1999
	02001 - 02200	American Falls	Little Camas Reservoir	June 1, 1999
	02201 - 02400	American Falls	Mann Creek Reservoir	June 3, 1999
	02401 - 02600	American Falls	Magic Reservoir	June 7, 1999
	02601 - 02800	American Falls	Hawkins Reservoir	June 8, 1999
	02801 - 03000	American Falls	Featherville Dredge Pond	June 14, 1999
	03001 - 03200	American Falls	Upper Payette Lake	June 21, 1999
	03201 - 03400	Hagerman (Riley Creek)	Lava Lake	May 17, 1999
	03401 - 03600	Hagerman (Riley Creek)	Dierkes Lake	May 18, 1999
	03601 - 03800	Hagerman (Riley Creek)	Mountain Home Reservoir	May 19, 1999
	03801 - 04000	Hagerman (Riley Creek)	Dog Creek Reservoir	May 20, 1999
	04001 - 04200	Hagerman (Riley Creek)	Park Center Pond	May 21, 1999
	04201 - 04400	Hagerman (Tucker Springs)	Sublett Reservoir	May 24, 1999
	04401 - 04600	Hagerman (Riley Creek)	Blair Trail Reservoir	May 25, 1999
	04601 - 04800	Hagerman (Riley Creek)	Cove Arm Reservoir	May 26, 1999
	04801 - 05000	Hagerman (Riley Creek)	Deep Creek Reservoir	May 27, 1999
	05001 - 05200	Hagerman (Riley Creek)	Roseworth Reservoir	June 2, 1999
	05201 - 05400	Hagerman (Riley Creek)	Little Camas Reservoir	June 1, 1999
	05401 - 05600	Hagerman (Riley Creek)	Mann Creek Reservoir	June 3, 1999
	05601 - 05800	Hagerman (Riley Creek)	Magic Reservoir	June 7, 1999
	05801 - 06000	Hagerman (Riley Creek)	Hawkins Reservoir	June 8, 1999
	06001 - 06200	Hagerman (Riley Creek)	Featherville Dredge Pond	June 14, 1999
	06201 - 06400	Hagerman (Tucker Springs)	Upper Payette Lake	June 21, 1999
	06401 - 06600	Hagerman (Tucker Springs)	Lava Lake	May 17, 1999
	06601 - 06800	Hagerman (Tucker Springs)	Dierkes Lake	May 18, 1999
	06801 - 07000	Hagerman (Tucker Springs)	Mountain Home Reservoir	May 19, 1999
	07001 - 07200	Hagerman (Tucker Springs)	Dog Creek Reservoir	May 20, 1999
	07201 - 07400	Hagerman (Tucker Springs)	Park Center Pond	May 21, 1999
	07401 - 07600	Hagerman (Riley Creek)	Sublett Reservoir	May 24, 1999
	07601 - 07800	Hagerman (Tucker Springs)	Blair Trail Reservoir	May 25, 1999
	07801 - 08000	Hagerman (Tucker Springs)	Cove Arm Reservoir	May 26, 1999
	08001 - 08200	Hagerman (Tucker Springs)	Deep Creek Reservoir	May 27, 1999
	08201 - 08400	Hagerman (Tucker Springs)	Roseworth Reservoir	June 2, 1999
	08401 - 08600	Hagerman (Tucker Springs)	Little Camas Reservoir	June 1, 1999
	08601 - 08800	Hagerman (Tucker Springs)	Mann Creek Reservoir	June 3, 1999
	08801 - 09000	Hagerman (Tucker Springs)	Magic Reservoir	June 7, 1999
	09001 - 09200	Hagerman (Tucker Springs)	Hawkins Reservoir	June 8, 1999

Appendix B. Continued.

Year	Tag Series[a]	Hatchery	Water	Date
	09201 - 09400	Hagerman (Tucker Springs)	Featherville Dredge Pond	June 14, 1999
	09401 - 09600	Hagerman (Riley Creek)	Upper Payette Lake	June 21, 1999
	09601 - 09800	Nampa	Lava Lake	May 17, 1999
	09801 - 10000	Nampa	Dierkes Lake	May 18, 1999
	10001 - 10200	Nampa	Mountain Home Reservoir	May 19, 1999
	10201 - 10400	Nampa	Dog Creek Reservoir	May 20, 1999
	10401 - 10600	Nampa	Park Center Pond	May 21, 1999
	10601 - 10800	Nampa	Sublett Reservoir	May 24, 1999
	10801 - 11000	Nampa	Blair Trail Reservoir	May 25, 1999
	11001 - 11200	Nampa	Cove Arm Reservoir	May 26, 1999
	11201 - 11400	Nampa	Deep Creek Reservoir	May 27, 1999
	11401 - 11600	Nampa	Roseworth Reservoir	June 2, 1999
	11601 - 11800	Nampa	Little Camas Reservoir	June 1, 1999
	11801 - 12000	Nampa	Mann Creek Reservoir	June 3, 1999
	12001 - 12200	Nampa	Magic Reservoir	June 7, 1999
	12201 - 12400	Nampa	Hawkins Reservoir	June 8, 1999
	12401 - 12600	Nampa	Featherville Dredge Pond	June 14, 1999
	12601 - 12800	Nampa	Upper Payette Lake	June 21, 1999
	18602	American Falls	Dierkes Lake	May 18, 1999
	18603	American Falls	Mountain Home Reservoir	May 19, 1999
	18604	American Falls	Mountain Home Reservoir	May 19, 1999
	18605	American Falls	Cove Arm Reservoir	May 26, 1999
	18606	American Falls	Mann Creek Reservoir	June 3, 1999
	18615	American Falls	Roseworth Reservoir	June 2, 1999
	19001	Hagerman (Riley Creek)	Hawkins Reservoir	June 8, 1999
2000	20001 - 20200	American Falls	Lava Lake	April 24, 2000
	20201 - 20400	American Falls	Dierkes Lake	April 25, 2000
	20401 - 20600	American Falls	Mountain Home Reservoir	April 26, 2000
	20601 - 20800	American Falls	Dog Creek Reservoir	April 27, 2000
	20801 - 21000	American Falls	Park Center Pond	April 28, 2000
	21001 - 21200	Hagerman (Riley Creek)	Deep Creek Reservoir	May 5, 2000
	21201 - 21400	Hagerman (Riley Creek)	Roseworth Reservoir	May 8, 2000
	21401 - 21600	Hagerman (Riley Creek)	Mann Creek Reservoir	May 9, 2000
	21601 - 21800	American Falls	Little Camas Reservoir	May 4, 2000
	21801 - 22000	American Falls	Deep Creek Reservoir	May 5, 2000
	22001 - 22200	American Falls	Roseworth Reservoir	May 8, 2000
	22201 - 22400	American Falls	Mann Creek Reservoir	May 9, 2000
	22401 - 22600	American Falls	Hawkins Reservoir	May 10, 2000
	22601 - 22800	American Falls	Magic Reservoir	May 11, 2000
	22801 - 23000	American Falls	Featherville Dredge Pond	May 12, 2000
	23001 - 23200	American Falls	Horsethief Reservoir	May 23, 2000
	23201 - 23400	Hagerman (Riley Creek)	Lava Lake	April 24, 2000
	23401 - 23600	Hagerman (Riley Creek)	Dierkes Lake	April 26, 2000
	23601 - 23800	Hagerman (Riley Creek)	Mountain Home Reservoir	April 27, 2000
	23801 - 24000	Hagerman (Riley Creek)	Dog Creek Reservoir	April 28, 2000
	24001 - 24200	Hagerman (Riley Creek)	Park Center Pond	April 29, 2000
	24201 - 24400	Hagerman (Riley Creek)	Blair Trail Reservoir	May 1, 2000

Appendix B. Continued.

Year	Tag Series[a]	Hatchery	Water	Date
	24401 - 24600	Hagerman (Riley Creek)	Sublett Reservoir	May 2, 2000
	24601 - 24800	Hagerman (Riley Creek)	Cove Arm Reservoir	May 3, 2000
	24801 - 25000	Hagerman (Riley Creek)	Little Camas Reservoir	May 4, 2000
	25001 - 25200	American Falls	Sublett Reservoir	May 2, 2000
	25201 - 25400	American Falls	Cove Arm Reservoir	May 3, 2000
	25401 - 25600	Hagerman (Riley Creek)	Hawkins Reservoir	May 10, 2000
	25601 - 25800	Hagerman (Riley Creek)	Magic Reservoir	May 11, 2000
	25801 - 26000	Hagerman (Riley Creek)	Featherville Dredge Pond	May 12, 2000
	26001 - 26200	Hagerman (Riley Creek)	Horsethief Reservoir	May 23, 2000
	26299	American Falls	Roseworth Reservoir	May 8, 2000
	26300	American Falls	Little Camas Reservoir	May 4, 2000
	26301 - 26400	American Falls	Blair Trail Reservoir	May 1, 2000
	26401 - 26600	Nampa	Lava Lake	April 24, 2000
	26601 - 26800	Nampa	Dierkes Lake	April 25, 2000
	26801 - 27000	Nampa	Mountain Home Reservoir	April 26, 2000
	27001 - 27200	Nampa	Dog Creek Reservoir	April 27, 2000
	27201 - 27400	Nampa	Park Center Pond	April 28, 2000
	27401 - 27600	Nampa	Blair Trail Reservoir	May 1, 2000
	27601 - 27800	Nampa	Sublett Reservoir	May 2, 2000
	27801 - 28000	Nampa	Cove Arm Reservoir	May 3, 2000
	28001 - 28200	Nampa	Little Camas Reservoir	May 3, 2000
	28201 - 28400	Nampa	Deep Creek Reservoir	May 5, 2000
	28401 - 28600	Nampa	Roseworth Reservoir	May 8, 2000
	28601 - 28800	Nampa	Mann Creek Reservoir	May 9, 2000
	28801 - 29000	Nampa	Hawkins Reservoir	May 10, 2000
	29001 - 29200	Nampa	Magic Reservoir	May 11, 2000
	29201 - 29400	Nampa	Featherville Dredge Pond	May 12, 2000
	29401 - 29600	Nampa	Horsethief Reservoir	May 23, 2000
	32701 - 32800	American Falls	Blair Trail Reservoir	May 1, 2000

[a] All tag numbers are preceded by the prefix “TR” (e.g. TR 00001)

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